This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

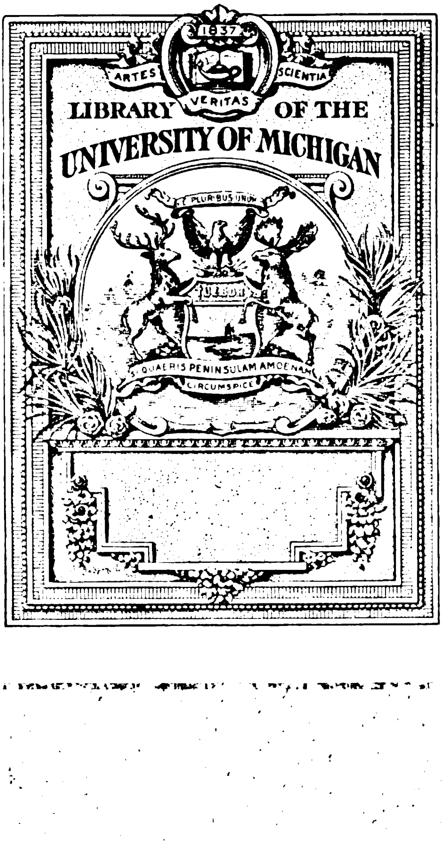
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

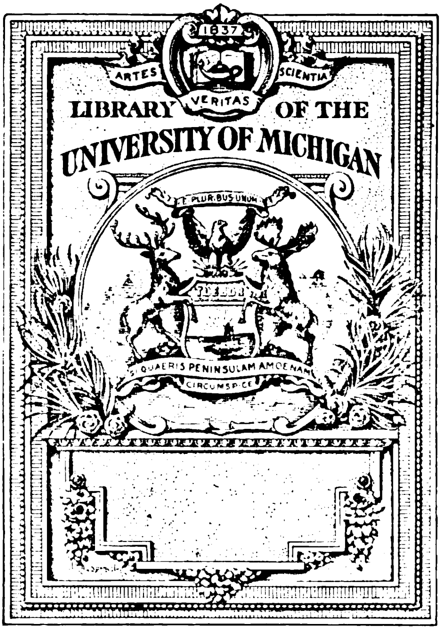
+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`


1837
ARTES
SCIENTIA
VERITAS
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
PLURIBUS UNUM
TUEBOR
SI QUAERIS PENINSULAM AMOENAM
CIRCUMSPICE

S
83
.E3



LIBRARY OF THE
UNIVERSITY OF MICHIGAN

S
83
.E3

BULLETIN NO. 1.

MONTANA
AGRICULTURAL
EXPERIMENT STATION

ORGANIZATION--ANNOUNCEMENTS.

BOZEMAN, MONTANA, MARCH, 1894.

Bozeman Chronicle,
Book and Job Printers.
1894.

MONTANA AGRICULTURAL

EXPERIMENT STATION.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman.
Peter Koch, Secretary and Treasurer	Bozeman.
George Kinkel, Jr., Vice President	Manhattan.
Walter Cooper	Bozeman.
E. H. Talcott	Livingston.

EXPERIMENT STATION STAFF.

S. M. Emery	Director and Horticulturist.
Luther Foster, M. S. A.	Agriculturist and Botanist.
F. W. Traphagen, Ph. D., F. C. S.	Chemist.
W. L. Williams, V. S.	Veterinary Surgeon.

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

Montana Experiment Station,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Experiment Station.

Bulletin No. 1. ◆ **March, 1894.**

ORGANIZATION--ANNOUNCEMENTS.

BY S. M. EMERY.

The Montana Agricultural Experiment Station owes its existence to the "Hatch Act" of 1887, creating experiment stations, supplemented by the passage by the Montana legislature in 1893 of the following law:

An act providing for the location and establishment of the Agricultural College of the State of Montana, and an Agricultural Experimental Station in connection therewith, enumerating its objects and purposes, dedicating lands for the use of the same, providing for the government and control thereof, and accepting and adopting the provisions, donations and benefits contained in the Acts of Congress relating thereto.

Be it enacted by the Legislative Assembly of the State of Montana:

SECTION 1. The Agricultural College of the State of Montana is established at the city of Bozeman, or within three (3) miles of the corporate limits of said city, upon such tract or tracts of land, conforming in the aggregate not less than eighty (80) acres, and as much more as shall be selected by the State Board of Education, as hereinafter provided; and said College has for its leading objects and purposes, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the

223903

mechanic arts, in such manner as the State Board of Education, and any subordinate board by such State Board appointed, may prescribe.

SEC. 2. It shall be the duty of the State Board of Education, within ninety (90) days from the date of the passage of this Act, if then organized, but if not organized then within ninety (90) days from the organization of the said Board, to select the site for the definite and permanent location of said Agricultural College of Montana and Agricultural Experimental Station, which site shall be at the city of Bozeman, or within three (3) miles of the corporate limits of said city of Bozeman; and said State Board of Education shall at once take steps or proceedings for procuring the title to the tract or tracts of land so selected by them, and they may, and are hereby empowered to enter into contracts in the name of the State of Montana, for the purchase of said tract or tracts of land so selected, and may execute such obligations for the payment of the same as will mature when the probable income from the fund of said Agricultural College and Agricultural Experimental Station, or either of them, will pay for the same. The said State Board of Education is hereby authorized and empowered to accept in the name of the State of Montana such gifts of land and money as may be tendered to aid in the purchase of said site, and whenever such gifts are sufficient in amount to secure or pay for said site they shall appropriate the same to that purpose, and take proper and necessary conveyances of said tract or tracts of land in the name of the State. All lands and money acquired, as provided in this section, shall be taken and held for the sole use and benefit of said Agricultural College and said Agricultural Experimental Station.

SEC. 3. The general control and supervision of such College is vested in the State Board of Education, which Board may prescribe all rules therefor.

SEC. 4. The Governor, by and with the advice and consent of the State Board of Education, may designate and appoint an Executive Board, consisting of five (5) members, at least three (3) of whom shall be residents of the county wherein said institution is situated, which Executive Board shall have the immediate direction and control of the affairs of said College, subject only to the general supervision and control of said State Board of Education. Such Executive Board shall serve during the term of the State Board of Education, unless sooner removed.

SEC. 5. The Executive Board is authorized to choose and appoint a president and faculty of said College, who shall serve as such, for such time, and receive such compensation as the said Executive Board may prescribe, subject to the approval of the State Board of Education.

SEC. 6. The Executive Board shall appoint a secretary thereof, who may also act as treasurer of said Board, and who may not be a member thereof, and such secretary and treasurer shall give bond with good and sufficient surety for the faithful performance of his duties as such, and for the faithful accounting for and paying over to the said Board of Education, to and for the use of said College, all monies received by him as treasurer, in such sum as said State Board of Education may prescribe.

SEC. 7. There is also located and established on the lands so to be selected by the State Board of Education, in connection with said Agricultural College, and under its direction, an Agricultural Experimental Station, to aid in acquiring and diffusing among the people of the State of Montana useful and practical information on subjects connected with agriculture, and to promote scientific investigation and experiments respecting the principles and application of agricultural science, which Experimental Station is established under and by virtue of the authority contained in the Act of Congress entitled "An Act to establish Experimental Stations in connection with the Colleges established in the several states, under the provisions of an act approved July 2d, 1862, and the said acts supplementary thereto," approved March 2d, 1887, and the provisions, donations and benefits contained in said Act of Congress, and in all other Acts of Congress relating to Agricultural Experimental Stations and Agricultural Colleges, now in force, and all acts supplementary thereto; or amendatory thereof, are by the State of Montana hereby accepted and adopted.

SEC. 8. Said Agricultural Experimental Station is hereby placed under the supervision and control of the State Board of Education, and the Executive or subordinate Board or authority who may be by the Governor, by and with the consent and advice of said Board of Education, appointed.

SEC. 9. This act shall take effect and be in force from and after its passage.

Approved February 16th, 1893.

THE EXECUTIVE BOARD.

According to law, Governor J. E. Rickards appointed the following persons: Lester S. Willson, Peter Koch, Walter Cooper, Geo. Kinkel, Jr., and E. H. Talcott, as members of the Executive Board of Education, in charge of the Agricultural Experiment Station of Montana.

This Board met and organized as follows: Lester S. Willson, President; Geo. Kinkel, Jr., Vice President; Peter Koch, Secretary and Treasurer.

THE EXPERIMENT STATION STAFF.

The appointments were duly confirmed by the State Board of Education, and the organization of the Experiment Station was completed by the selection of the following as members of the Experiment Station staff: S. M. Emery, Director and Horticulturist; Luther Foster, M. S. A., Agriculturist and Botanist; F. W. Traphagen, Ph. D., F. C. S., Chemist; W. L. Williams, V. S., Veterinary Surgeon.

AGRICULTURAL COLLEGE AND EXPERIMENT STATION SITES.

On March 22, 1893, the State Board of Education met at Bozeman in joint session with the Executive Board, to consider and select a suitable building site and grounds for the Agricultural College, and a farm for the use of the Experiment Station. After considering the various tracts offered, a choice was made of blocks No. 22, 23, 24, 25, 26 and 27, Capitol Hill Addition to the City of Bozeman, for the location of the Agricultural College grounds, the purchase price of the same being a gift from the Hon. Nelson Story, of Bozeman, a member of the State Board of Education, and a staunch friend of advanced practical education.

These blocks comprise, with the streets and alleys (the vacation of which is contemplated), about twenty acres of land, in the southwestern part of the city of Bozeman, and occupy perhaps the most commanding location in or about the city, overlooking, as they do, the city, its surroundings, and the entire valley of the various branches of the Gallatin river, the view only being circumscribed by the Bridger, Gallatin and Madison ranges of mountains.

As the site for the Experiment Station farm, the northwest quarter of section 13, township 2 south, range 5 east, lying directly west and contiguous to the college site, was selected.

This tract of land has been the property of Gallatin county for ten years, having been used during this time as a county poor farm. A nominal price was made to the state, thus being conveyed to the state for the use of the Experiment Station as a joint donation of the city of Bozeman and Gallatin county.

The joint tract is situated 4,000 feet from the Gallatin county Court House, in Bozeman, and directly upon the electric street car line, and within easy reach of the city water works and electric light system.

Its accessibility to the city and the main line of the Northern Pacific Railway, add immeasurably to the benefits to be derived from the work of these institutions to the citizens of Montana.

The college grounds proper is virgin soil, rich and productive, and will respond readily to the art of the landscape gardener, in reducing the unbroken soil to a lawn condition, and in establishing trees and shrubs for shelter and ornament.

THE EXPERIMENT STATION FARM.

The farm property has been considered as an attachment to the care of the county paupers, and its cultivation has not been such as to leave it in a high state of fertility. With the farm is a water right to 100 inches of water from the Middle Creek Ditch company, offering, under judicious use, an ample supply of water for irrigation and stock purposes.

Portions of the farm are badly washed by the action of waste water, and the ditches were grown up to willows and sage brush. These were cleaned out, and superfluous ditches have been plowed and filled in.

The highway between Bozeman and Salesville traverses the farm diagonally; and an attempt is being made to close this, and open a new road on the south section line, thus leaving the tract in a solid body.

The farm offers a variety of soils and conditions. Upon the southeast forty acres is a marshy tract some six acres in extent. This is apparently underlaid with wash gravel, the surface being of peat or light alluvial soil, and is too spongy to permit cultivation. It carries a good crop of wild hay, but is impassable to team and mower. This is caused by seepage from springs in the vicinity, and the wastage from irrigation ditches. It will afford the opportunity for experiment with tile drainage, with the object of making a tame meadow, and also to add to the artificial water supply of the farm.

The southwest and northwest forty acre tracts are traversed from south to north by two irregular draws, or channels, about two rods in width, the substratum of which seem to be wash gravel, with a top soil of vegetable loam. These low places have never been cultivated, and at present produce a fair crop of timothy. There are some surface stone over a large portion of the farm. It is proposed to plat the farm into ten acre blocks, and to make a topographical plat of each, showing character and composition of soil in each block.

With the system of summer fallowing prevalent in the Gallatin valley, the farm has usually produced good crops, the average for 1893 being 73 bushels of oats to the acre. We are not in full sympathy with the plan of summer fallowing. It is doubtless a necessity in strictly grain farming, but it is at best an expensive process, requiring, as it does, two acres of land to perform the work of one.

It has been claimed that early maturing crops (permitting the land to be plowed at an early date in the summer) or early summer fallowing, in sections subject to rainfall, is a positive injury, from the loss of nitrogen to the soil filtered away by the action of water.

It is proposed, on these accounts, to experiment with the various clovers and field peas, these being nitrogeneous crops, and very valuable, either as green manures or in promoting the extension of two leading branches of agriculture, dairy husbandry and swine, and in this manner to reduce the areas of land that are productive only once in two years.

FARM IMPROVEMENTS.

The buildings upon the farm are poor in quality, and unsuitable to the purposes of an experiment station, and suitable buildings must be provided by state aid.

The fences enclosing the tract are poor in quality and in bad condition, and will be replaced by a galvanized close set wire fence, five strands, upon first class red cedar posts.

Plans are being drawn for the erection of an Experiment Station building, which will be a basement and two stories, stone foundation, frame with brick veneer, 44 by 50 feet, with accommodations for the director and horticulturist, the professor of agriculture and botany, the chemist and the veterinarian. Class rooms will also be provided for work shops for those students taking iron and wood work in the College, and for instruction in mechanical drawing.

This building can be paid for from the fund derived from the annual appropriation of the United States government, under the Hatch Experiment Station law, portions of which read as follows:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That in order to aid in acquiring and diffusing among the people of the United States useful and practical information on subjects connected with agriculture, and to promote scientific investigation and experiment respecting the principles and applications of agricultural science, there shall be established, under direction of the college or colleges, or agricultural department of colleges in each state or territory established, or which may hereafter be established, in accordance with the provisions of an act approved July second, eighteen hundred and sixty-two, entitled "An Act donating public lands to the several states and territories which may provide colleges for the benefit of agriculture and the mechanic arts," or any of the supplements of said act, a department to be known and designated as an "Agricultural Experiment Station." * * *

SEC. 2. That it shall be the object and duty of said experiment stations to conduct original researches or verify experiments on the physiology of plants and animals; the diseases to which they are severally subject, with the remedies for the same; the chemical composition of useful plants at their different stages of growth; the comparative advantages of rotative cropping as pursued under a varying series of crops; the capacity of new plants or trees for acclimation; the analysis of soils and water; the chemical composition of manures, natural or artificial, with experiments designed to test their comparative effects on crops of different kinds; the adaptation and value of grasses and foliage plants; the composition and digestibility of the different kinds of food for domestic animals; the scientific and economic questions involved in the production of butter and cheese; and such other researches or experiments bearing directly on the agricultural industry of the United States as may in each case be deemed advisable, having due regard to the varying conditions and needs of the respective states or territories.

SEC. 3, * * * It shall be the duty of each of said stations, annually, on or before the first day of February, to make to the governor of the state or territory in which it is located a full and detailed report of its operations, including a statement of receipts and expenditures, a copy of which report shall be sent to each of said stations, to the said commissioner of agriculture, and to the secretary of the treasury of the United States.

SEC. 4. That bulletins or reports of progress shall be published at said stations at least once in three months, one copy of which shall be sent to each newspaper in the states or territories in which they are respectively located, and to such individuals actually engaged in farming as may request the same, and as far as the means of the station will permit.

* * * *

SEC. 5. That for the purpose of paying the necessary expenses of conducting investigations and experiments, and printing and distributing the results, as hereinbefore prescribed, the sum of fifteen thousand dollars per annum is hereby appropriated to each state, to be specially provided for by congress in the appropriations from year to year, and to each territory entitled under the provisions of section eight of this act, out of any money in the treasury proceeding from the sales of public lands, to be paid in equal quarterly payments, on the first day of January, April, July and October in each year, to the *treasurer* or *other officer* duly appointed by the governing boards of said colleges to receive the same, the first payment to be made on the first day of October, eighteen hundred and eighty-seven: *Provided, however*, That out of the first annual appropriation so received by any station, an amount not exceeding one-fifth may be expended in the erection, enlargement or repair of a building or buildings necessary for carrying on the work of such station; and thereafter an amount not exceeding five per centum of such annual appropriation may be so expended.

SEC. 6. That whenever it shall appear to the secretary of the treasury from the annual statement of receipts and expenditures of any of said stations that a portion of the preceding annual appropriation remains unexpended, such amount shall be deducted from the next succeeding annual appropriation to such station, in order that the amount of money appropriated to any station shall not exceed the amount actually and necessarily required for its maintenance and support.

SEC. 9. That the grants of moneys authorized by this act are made subject to the legislative assent of the several states and territories to the purposes of said grants. * *

In the donation to the State of Montana of an Agricultural College site by a private citizen, and the gift of one hundred and sixty acres, by cash contributions from citizens of Bozeman, and the commissioners of Gallatin county; also the prompt and efficient discharge of the onerous official duties of the Executive Board of Education, in which there is more of honor than profit; and further, by the liberality of the school board of the City of Bozeman in supplying the Agricultural College and Experiment Station with the free use of a large part of the Bozeman high school building, it is considered that Gallatin county and the city of Bozeman have done their duty well and faithfully by these institutions, and that the proper further development of these state institutions, open to all in the state, of sufficient scholastic age and attainments, becomes the proper work of the State of Montana.

THE MORRILL ACT.

The Agricultural College appropriation is derived from the Morrill Act, which reads:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there shall be and hereby is annually appropriated, out of any money in the treasury not otherwise appropriated arising from the sales of public lands, to be paid as hereinafter provided, to each state and territory for the more complete endowment and maintenance of colleges for the benefit of agriculture and the mechanic arts now established, or which may be hereafter established, in accordance with an act of Congress approved July second, eighteen hundred and sixty-two, the sum of fifteen thousand dollars for the year ending June thirtieth, eighteen hundred and ninety, and an annual increase of the amount of such appropriation thereafter for ten years by an additional sum of one thousand dollars over the preceding year; and the annual amount to be paid thereafter to each state and territory shall be twenty-five thousand dollars, to be applied only to instruction in *agriculture, the mechanic arts, the English language, and the various branches of mathematical, physical, natural and economic science*, with special reference to their applications in the industries of life, and to *the facilities for such instruction*. * * *

SEC. 2. That the sums hereby appropriated to the states and territories for the further endowment and support of colleges shall be annually paid on or before the thirty-first day of July of each year, by the secretary of the treasury, upon the warrant of the secretary of the interior, out of the treasury of the United States, to the state or territorial treasurer, or to such officer as shall be designated by the laws of such state or territory to receive the same, who shall, upon the order of the trustees of the college, * * * *immediately pay over said sums to the treasurers* of the respective colleges or other institutions entitled to receive the same, and such treasurers shall be required to report to the secretary of agriculture and to the secretary of the interior, on or before the first day of September of each year, a detailed statement of the amount so received and of its disbursement. The grants of moneys authorized by this act are made subject to the legislative *assent of the several states and territories* to the purpose of said grants. * *

SEC. 3. * * * An annual report by the president of each of said colleges shall be made to the secretary of agriculture, as well as to the secretary of the interior, regarding the condition and progress of each college, including statistical information in relation to its receipts and expenditures, its library, the number of its students and professors, and also as to any improvements and experiments made under the direction of any experiment stations attached to said colleges, with their costs and results, and such other industrial and economical statistics as may be regarded as useful, one copy of which shall be transmitted by mail free to all other colleges further endowed under this act.

SEC. 4. That on or before the first day of July in each year, after the passage of this act, the secretary of the interior shall ascertain and certify to the secretary of the treasury as to each state and territory whether it is entitled to receive its share of the annual appropriation for colleges, * * * under this act, and the amount which thereupon each is entitled, respectively, to receive. * * * And the secretary of the interior is hereby charged with the proper administration of this law.

STATE AID FOR IMPROVEMENTS.

The manifest design of the national government in making appropriations under the Hatch Act and the Morrill Act was to supplement the efforts of the various states and territories along the lines of practical education. It was no part of the intention of those responsible for these acts to provide in whole for funds to establish these institutions. To the contrary, the laws, and the interpretation of the same by the officials of the United States treasury, is that lands and buildings (except $3,000 of the first year's appropriation under the Hatch Act, and $750 each year thereafter, may be used in construction and repair of station buildings,) fuel, janitor service, and furniture must be provided otherwise than by government funds; and the material work of this Station must depend largely upon state, or other public or private aid.

The establishment of suitable farm buildings, for labor, barns for work horses and experiments in feeding, dairy, poultry and swine buildings, all prime essentials to the successful prosecution of agricultural experimentation of prime importance to the state, rest and depend upon the financial aid that must be extended to the Station by the State of Montana.

At the present writing the director and horticulturist, the agriculturist and botanist, and the veterinary surgeon, are provided quarters by the courtesy of the school board of the city of Bozeman in the high school building, and the chemist is stationed in the building formerly occupied by the Bozeman Academy.

FARMERS' INSTITUTES.

The members of the Station staff have been engaged a large part of the time upon institute work, having conducted farmers' institutes at the following points: Bozeman, Spring Hill, Manhattan, Willow Creek, South Boulder, Whitehall, Waterloo, Sheridan, Twin Bridges, Ennis, Meadow Creek, Townsend, Great Falls, Stevensville, Hamilton and Missoula. At the majority of these points a warm interest has been displayed by the farmers in the work, and there is good promise of beneficial results from the work.

This work is independent of the regular routine work of the staff, and has voluntarily been assumed and carried on for the following reasons: *First*, The depression attendant upon adverse legislation upon the silver mines and the sheep industry, compel the development of other industries, and that of agriculture being the most promising and beneficial to the state, demands the attention especially of Station workers.

Second, The efficiency of the Station can best be served by the intimate acquaintance of the staff with the farmers in the various sections of the state, and a personal study of the conditions governing the various localities. Aside from the results to the localities visited, the information acquired by the staff has been ample to warrant the effort.

AGRICULTURAL DEPARTMENT.

The work of the Agricultural Department,.for the present, will be confined to the following lines:

(1) The adaptation and value of the different cereals, grasses and other forage plants; incident to this, the treatment for smuts in wheat and oats, preparation of the seed-bed, time and methods of seeding, a comparative test of varieties, and the use of stable manures.

(2) Some of the various unsettled questions of irrigation, viz.: The economic use of water, its effect on the fertility of the soil and on the quality of various crops, especially hard wheat. Also the effect of previous crops and cultivation on the quantity of water required.

(3) Feeding experiments, with special reference to economic meat and milk production from Montana foods.

(4) Dairying; experiments in handling and testing milk, creaming, churning, feeding, improvement of the Montana cow for dairy purposes, and any other work that will tend to encourage and develop dairy husbandry in this state.

(5) Potato culture; time and methods of seeding and cultivating, best effects of irrigation, and the prevention of disease.

DEPARTMENT OF VETERINARY SCIENCE.

In the Department of Veterinary Science it is intended to conduct experiments with animal diseases, especially with those peculiar to Montana and other Rocky mountain states, with a view to learning, if possible, the causes of these affections, and some practical means for their prevention.

As early as circumstances will permit, it is intended to provide suitable buildings and equipment upon the Station farm, where animal diseases may be advantageously studied at all seasons of the year. For the present, however, the work must be largely confined to field investigations, the Veterinarian visiting from time to time interesting outbreaks of animal disease, in so far as circumstances and other duties may permit, and making personal investigations.

In order that such work may prove of the greatest value to the live stock interests of the state, the hearty co-operation of stock owners is essential. It is consequently desired that persons owning or having knowledge of animals affected with some prevalent form of disease, the nature and cause of which is unknown, will promptly communicate all known facts regarding the disease to the Station Veterinarian, so that he may learn of the prevalence of these diseases in the various localities of the state, and be in a position to select the most favorable localities for personal investigations regarding the nature of the various affections.

DEPARTMENT OF CHEMISTRY.

The Department of Chemistry will be occupied with work, in conjunction with the Agriculturist, in the analysis of foods used in stock feeding experiments, for the purpose of showing the relative value of the various native grasses, and of other cattle foods grown in the state.

A chemical examination of the so-called "loco" weeds, with their effects upon domestic animals, is projected by the Veterinarian and Chemist conjointly.

A detailed study of the soils of the state will extend over a considerable period, and include samples from all parts of the State. Directions for taking such samples will be distributed as early as possible.

Other work to be done is in the line of analysis of dairy products, milk, butter and cheese, with the aim of improving both stock and product.

3[illegible].6[illegible]9
M92b

BULLETIN NO. 2.

UNIV. OF MICH.
JAN 18 1909

MONTANA

AGRICULTURAL

EXPERIMENT STATION

SMUTS OF WHEAT, OATS AND BARLEY.

Bozeman, Montana, May, 1894.

BOZEMAN, MONT.
THE AVANT COURIER.
1894.

MONTANA AGRICULTURAL

EXPERIMENT STATION.

EXECUTIVE BOARD.

LESTER S. WILLSON, President	Bozeman.
PETER KOCH, Secretary and Treasurer	Bozeman.
GEORGE KINKEL, JR., Vice-President	Manhattan.
WALTER COOPER	Bozeman.
E. H. TALCOTT	Livingston.

EXPERIMENT STATION STAFF.

S. M. EMERY	Director and Horticulturist.
LUTHER FOSTER, M. S. A.	Agriculturist and Botanist.
F. W. TRAPHAGEN, Ph. D., F. C. S.	Chemist.
W. L. Williams, V. S.	Veterinary Surgeon.

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

MONTANA EXPERIMENT STATION,
Bozeman, Montana.

NOTICE: The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Experiment Station.

Bulletin No. 2. - - - May, 1894.

SMUTS OF WHEAT, OATS AND BARLEY.

BY LUTHER FOSTER.

EXTENT OF DAMAGE.

The smuts of the small grains, especially of wheat and oats, is a subject of more than ordinary importance to the farmers of this State, because of the large annual loss that may be easily prevented, at little expense, when the nature of the disease and the manner of infecting the plant are well understood.

In Bulletin 15, of the Kansas Station, Professors Kellerman and Swingle report as a result of numerous counts made in oat-fields, on different kinds of soil in that State, an average annual loss of 13 per cent. Figuring on this basis they show the loss from loose smut in oats, in that State alone for the three years, 1888, 1889, 1890, reached the enormous sum of over six million two hundred thousand dollars. They report the damage from stinking smut in wheat at a much higher per cent., in some cases destroying more than half of the crop.

Prof. Arthur, in Bulletin 35, of the Indiana Station, says:

"The Experiment Station is cautious about the seed used on its farm, yet by actual count in different parts of several fields, the oat crop showed 18.4 per cent. of smut. But, on account of the contracted heads and short straw of the affected plants, these fields did not appear noticeably smutty, and would not have suggested to a casual observer anything unusual or especially indicative of loss."

Estimating the average loss of the State at 10 per cent., only slightly more than half the rate determined by actual count, he reports the loss from smut, in the Indiana oat crops of 1889 and 1890, as a trifle less than five million bushels. In Bulletin 32, on treatment for smut in wheat, he reports that a loss of one-half the crop in certain fields has not been uncommon and that a careful inspection shows many fields affected where smut was not supposed to exist.

As U. S. Commissioner of Agriculture, Hon. Norman J. Colman, after making a careful, comprehensive investigation of the subject, said in his report:

"We may safely assume that the value of the wheat and corn annually destroyed in this country by diseases induced by fungi is not less than $200,000,000."

Farmers' Bulletin No. 5, issued by the U. S. Agricultural Department, estimates that a universal system of seed treatment in the United States would have saved the farmers a net amount of $162,457,000, from 1880 to 1890, on the oat crop alone.

Hon. A. C. Clausen, chief grain inspector of Minnesota, reports thirty per cent. of the 100,000,000 bushels of wheat marketed in the Northwest in 1893, as smutty and a consequent loss of two to twelve cents per bushel on all such damaged grain. This, taking the average, seven cents per bushel, indicates a loss of seven million dollars directly to the farmers of this section on the one season's wheat crop.

It will be seen that Mr. Clausen's estimate does not include the loss in yield caused by the smut and that in most of the other reports the loss in yield alone is considered and no account taken of the lower market value. The disease, then, results in a double loss, especially to the wheat crop, coming from a smaller yield and a less price per bushel.

The finely powdered smut scattered through the wheat in threshing and the penetrating, offensive odor that it gives, cannot be completely removed by any milling process, hence the market value is lessened.

Since all of the estimated losses given above are deduced from only one or the other of these two equally important sources, one may safely conclude that the estimates are none too great. In my own experiments at the South Dakota Station, I found that the varieties of soft wheat were damaged to a greater extent than those of the hard and seemed more susceptible to the disease. Considering this and the fact of the soft varieties being largely grown in this State, our gain from the general eradication of smuts would be proportionately as great as in any of the States referred to above.

All Experiment Station authorities agree that the disease may be effectually eradicated with very little outlay except in labor, and the enormous aggregate annual loss be thus saved to the grain growers.

Since the law of Congress provides for the dissemination of useful knowledge by the Stations other than that resulting from their own investigations, I shall endeavor to place in the hands of Montana farmers such practical information on this subject as can be derived from experiments made elsewhere, both by myself and other Station workers.

CAUSE OF THE DISEASE.

The disease is caused by a parasitic fungus which grows in the tissues of the plant and feeds upon its juices, finally converting the nourishment intended for the production of grain into dark masses of minute spores known as smut.

The spores which serve the same purpose as seeds, are exceedingly small and can be seen only by the aid of the microscope. These spores are scattered by the winds, in the field or during threshing, and become attached to the grains. When the seed is sown, the spores of smut germinate and send out minute threads, which enter the delicate young plant. These threads penetrate all parts of the stem, their growth keeping pace with that of the plant, until they enter the head and produce an immense number of spores in the places that otherwise would have been filled with grains. The loose smuts are not confined to the grain, the whole head or panicle usually being destroyed as well.

STINKING SMUT OF WHEAT.

This disease is also known in some localities as bunt, or hard smut. It is always readily detected by its peculiar, offensive odor, and the miller depends on this characteristic to determine its presence in wheat offered for milling. In the grain field, before the plants have headed out, it can only be detected by an expert and even then it is ordinarily overlooked. The infected heads differ but little, if any, from the healthy ones until the grain has swollen and broken open the chaff, exposing the grayish-brown or dark kernel within.

Very little smut is sufficient to condemn wheat for milling purposes, on account of the penetrating, fetid odor and the dark color it gives the flour. It may not only greatly reduce the yield, but also materially damage the milling qualities of the harvested product, rendering it unsalable and worthless for flour making.

LOOSE SMUTS.

There are two quite distinct classes of smuts; the stinking smut, described above, which is found only in wheat, and the loose or black smut, which attacks all the small grains, but confines its principal injury to the oat crop. The loose smut is not confined to the grains as the stinking smut, but frequently converts the whole head into a loose mass of spores, leaving scarcely enough tissue to hold it together.

Before heading out, the diseased plants would not usually be considered as differing from those not affected.

After the smut makes its appearance, it develops very rapidly and soon ripens. Under the influence of wind and rain it gradually disappears, usually leaving the stalks bare long before the grain ripens. These loose spores, blown about by the wind, attach themselves to the grains, where they remain ready to germinate with them when planted.

LOOSE BARLEY SMUTS.

The Kansas Station's report on "Loose Smuts of Cereals," discusses two kinds of barley smut, the *covered* and the *naked*. From this we learn that the covered barley smut differs from all other loose smuts, in that the attacked panicle is not at once converted into a powdery mass by the escape of the smut, but the smut remains more or less completely inclosed by a membrane which is not nearly so fragile as in the case of the open barley smut or the loose smut of wheat and oats. This membrane retains the smut for some time, finally allowing it to escape through rents and fissures. The spores themselves seem more or less firmly glued together, preventing their rapid escape. On account of this adhering quality and its tendency to remain inclosed, it is not blown about by the winds and is much less infectious than other smuts.

The naked barley smut is more common. It resembles the loose smuts of wheat and oats in converting the whole panicle into a loose powdery mass of spores which are readily scattered by the winds.

The covered smut is readily killed by treating with copper sulphate or hot water, the same as in wheat and oats.

For naked barley smut, Kellerman and Swingle strongly recommend the following treatment, based on the numerous experiments of Jensen:

"Soak the barley seed *four hours* in cold water and then let it stand *four hours longer* in a wet sack. Finally dip and drain as *directed in the treatment for oat smut* for five minutes in water of a temperature of 126° to 128° F., after which dry and plant as in case of oats.

"The temperature must not be above 128°, since the soaked seed would then be injured, and not below 126°, for then not all the smut would be killed. Both vessels should contain water of this temperature. Instead of soaking four hours and letting the seed stand four hours longer in a wet sack, it may be simply soaked eight hours, drained and then treated with hot water."

METHODS OF TREATMENT.

The treatment is based on the belief that the main source of smut lies in the spores attached to the seed and that the likelihood of infection from smut left on the ground from the previous crop is very slight. The treatments recommended are such as will kill the smut spores adhering to the seed without material damage to the fertility of the grain. The two processes best known are the *Copper Sulphate* and the *Hot Water* treatments, either of which, properly carried out, is entirely successful.

COPPER SULPHATE (BLUE-VITRIOL) TREATMENT.

This is no doubt the simplest and perhaps the most universal method, still it must be admitted that it lessens in some degree the germinating power of the seed.

Different experimenters advocate solutions varying much in strength. The grain must remain immersed a number of hours in the weak solutions while only a few minutes in the strong. In my own experiments, the following plan proved very successful:

Make a solution using eight ounces of blue-stone to one gallon of water. This will be enough to thoroughly wet up about four bushels of grain. The solution may be made very rapidly by using warm water and breaking the blue-stone into fine particles. Spread the grain on a clean floor or in a tight wagon box and apply the solution with a sprinkler. Stir the grain during the application and long enough afterward to bring every kernel in contact with the solution.

If the grain be well spread out after treatment and stirred occasionally, it will be ready to drill in a few hours. Many follow the plan of treating the grain each evening for the next day's sowing.

Dipping the grain into the solution will, of course, answer the same purpose, if the sack or dipping vessel is agitated sufficiently to wet the kernels evenly.

HOT WATER TREATMENT.

The discovery of this remedy was made by a Danish scientist, Prof. J. L. Jensen, of Copenhagen, and after him it is usually called the "Jensen method".

The following are the directions for treating oats by this method, as published by the Kansas Station:

"The hot-water treatment consists in immersing the seed which is supposed to be infected with smut, for a few minutes in scalding water. The temperature must be such as to kill the smut spores, and the immersion must not be prolonged so that the heat would injure the germ or embryo concealed within the seed-coats. If the water is at a temperature of 132½° F., the spores will be killed, and yet the immersion, if not continued beyond fifteen minutes, will not in the least injure the seed. The smut spores will possibly be killed by ten minute's immersion. A fifteen-minute immersion, however, is recommended. The temperature must be allowed to vary but little from 132½°, in no case rising higher than 135°, nor falling below 130°. To insure these conditions when treating large quantities of seed, the following suggestions are offered:

"Provide two large vessels, as two kettles over a fire, or boilers on a cook-stove; the first containing warm water (say 110°—130°), the second containing scalding water (132½°).

"The first is for the purpose of warming the seed preparatory to dipping it into the second. Unless this precaution is taken, it will be difficult to keep the water in the second vessel at a proper temperature.

"The seed which is to be treated must be placed, a half bushel or more at a time, in a closed vessel that will allow free entrance and exit of water on all sides. For this purpose a bushel basket made of heavy wire could be used, within which spread wire netting, say 12 meshes to the inch; or an iron frame could be made at a trifling cost, over which the wire netting could be stretched. This would allow the water to pass freely, and yet prevent the passage of the seed. A sack made of loosely-woven material (as gunny-sack) could perhaps be used instead of the wire basket. A perforated tin vessel might be preferable to any of the above.

"Now dip the basket of seed in the first vessel; after a moment lift it; and when the water has for the most part escaped, plunge it into the water again, repeating the operation several times. The object of the lifting and plunging, to which might be added also a rotary motion, is to bring every grain in contact with the hot water. Less than a minute is required for this preparatory treatment, after which plunge the basket of seed into the second vessel. If the thermometer indicates that the temperature of the water is falling, pour in hot water until it is elevated to 132½°. If it should rise higher than 132°, add small quantities of cold water. This will doubtless be the most effectual method of keeping the proper temperature, and requires only the addition of two small vessels—one for cold and the other for boiling water. The basket of seed should, very shortly after its immersion, be lifted, and then plunged and agitated in the manner described above; and the operation should be repeated eight to ten times during the immersion (which should be continued fifteen minutes). In this way every portion of the seed will be subjected to the action of the scalding water. Immediately after its removal dash cold water over it, or plunge it into a vessel of cold water, and then spread out to dry. Another portion can be treated similarly, and so on till all the seed has been disinfected. Before thoroughly dry, the seed can be sown,

"The important precautions to be taken are as follows: 1st. *Maintain the proper temperature* of the water (132½° Fahr.), in no case allowing it to rise higher than 135° or to fall lower than 130°. This will not be difficult to do if a reliable themometer is used and hot or cold water be dipped into the vessel as the rising or falling temperature demands.

Immersion fifteen minutes will not then injure the seed. 2d. See that the volume of scalding water is much greater (at least six or eight times) than that of the seed treated at any one time. 3rd. Never fill the basket or sack containing the seed entirely full, but always leave room for the grain to move about freely. 4th. Leave the seed in the second vessel of water *fifteen minutes.*"

The same authorities recommend that for wheat the temperature be maintained at 131° F., instead of 132½° F.; otherwise the method is the same.

POTASSIUM SULPHIDE TREATMENT FOR OATS.

Experiments at the Kansas Station leave no doubt as to the efficacy of this treatment for loose smut in oats, since it completely destroyed the smut, without in any way damaging the vitality of the seed.

In Bulletin 15 of that Station, this treatment is represented as nearly, if not quite, as good as the hot water treatment for oats.

Since this method may prove more convenient than the Jensen treatment, for those who sow small quantities of oats, it is given here as detailed in Farmers' Bulletin No. 5 of the United States Agricultural Department.

"In this treatment the seed is left twenty-four hours in a one-half per cent. solution of potassium sulphide. The published experiments seem to show that a weak solution of potassium sulphide is nearly as good as the hot water. The potassium sulphide is cheapest in the "fused" condition, in which form it costs about 25 cents a pound. One pound of the sulphide should be dissolved in 24 gallons of water. Place the seed in a *wooden vessel* and pour on the solution till the seed is covered several inches deep. Stir the solution before pouring it on the grain and thoroughly mix the seed several times before taking it out of the solution. The oats should stand in the solution twenty-four hours, after which they may be spread out to dry. The solution gradually loses its strength and hence cannot be used more than three or four times without being renewed.

It will probably be best to sow the seed as soon as possible and before it becomes thoroughly dry.

Soaking the seed twelve hours in a solution of twice the strength will no doubt prove effectual."

DISCUSSION OF METHODS.

Kellerman and Swingle, of Kansas Station:

"The treatment of seed with hot water by the Jensen method completely prevented the smut in every case, and improved rather than diminished the germinating power of the seed and the vigor of the plant."

"Treatment of seed oats with hot water or with potassium sulphide, both prevents the smut and increases the yield. It increases the yield, however, not merely by the amount which equals the grain actually destroyed by the smut, but by at least twice that amount."

"Treatment with a solution of copper sulphate, 4 ounces to the gallon, for 18 hours, prevented the smut but greatly injured the seed."

"Of the many forms of the treatment (copper sulphate) in use, perhaps the best is to immerse the seed 12 to 15 hours in a one-half per cent. solution and then put the seed for five or ten minutes in lime water. This, if properly carried out, will prevent the smut, with but little injury to the crop. But the germinating power of the seed is somewhat lessened, and in many cases the young plants are weakened by this treatment."

"We account for the increased yield above the amount of direct damage from smut by assuming that the Jensen treatment caused the seed to germinate better. Jensen gives a similar view, saying 'I suppose this remarkable fact must be due to a greater vegetative energy in the treated seed.'"

"In all ordinary cases the disease can be entirely prevented by treating the seed (oats) 15 minutes in water raised to a temperature of 132½° F."

"Stinking smut of wheat is effectually prevented by treating the seed with water at a temperature of 131° F., 15 minutes. For cheapness, as well as for greater efficiency, without injury to seed, this is recommended above all other fungicides."

"Soil treated with manure and smut the previous August and also soil simply smutted at the same time, actually gave a less per cent. of smut than untreated soil. This result is unexplainable, unless it can be referred to the immediate plowing which the other plots did not receive."

Prof. Ingersoll, of Neb., in Bulletin No. 32 says:

"The following is the prescription:

"4 ounces of blue-vitriol (copper sulphate).

"1 gallon of water.

"Fill a barrel two-thirds full of the solution. Dip the wheat thoroughly so that all the wheat grains are well soaked; ten minutes will probably suffice. Use a gunny sack or some other old sack and arrange a drip shelf so that the fluid drip will run back into the barrel. Renew the strength of the solution and the quantity from time to time so as to do the work with thoroughness. The smut may not all leave the first year, but two or three years of persistent effort will cause it to succumb and be practically annihilated. Hot water and other remedies have been recommended, but an experience of nine years, where this treatment of seed was persisted in by the best farmers, shows a uniformity of good results, and that the above formula is an excellent remedy."

Prof. Arthur, of Ind., and Prof. Bolley, of N. D.. both recommend a copper sulphate solution of one pound to a gallon of water and an immersion of five minutes.

Prof. Arthur says, Bulletin Nos. 32 and 35:

"The copper sulphate treatment consists in dipping the seed into a solution of one pound to one gallon of water, letting it remain five minutes with constant stirring to wet the grain evenly, and then spreading on the floor to dry, or shoveling over with the addition of land plaster or slacked lime until dry."

"This treatment will prevent all or nearly all occurrence of smut in the crop following, it will also, however, somewhat retard the early growth of the grain, and may somewhat decrease the yield."

Concerning the Jensen method he says:

"From all the data at hand we arrive at the conclusion that to treat seed wheat with hot water in order to prevent smut it should be immersed for five minutes in water at 135° F.; if the temperature drops below this point the seed should be left in the water a little longer time, and if the temperature rises above it, the time should be shortened. A greater variation than five degrees above or below the 135° F., should be guarded against."

The following concludes his bulletin on loose smut of oats:

"It appears from the preceding results obtained from the field and laboratory, viewed from several stand-points, that there can be no question of the superiority of the hot water treatment over the copper sulphate one, both being thoroughly efficacious in preventing smut when properly applied, but the latter retards the growth and decreases the yield, while the former accelerates the growth and increases the yield."

Prof. Hays, of the Minn. Station, gives the following remedy and says it is essentially the method recommended by Prof. Saunders, of the Canada Station:

"Dissolve one pound of the blue-stone (copper sulphate) in a pailful and a half of water (about three gallons), and sprinkle the solution on about ten bushels of seed wheat, previously spread in a tight wagon box, or on a clean floor in barn or house, keeping the grain constantly stirred while the solution is being applied, and mixing the whole thoroughly so that every kernel of wheat may be wetted. In a very few hours the seed will be in good condition to sow with the drill."

The following is quoted from Farmers' Bulletin No. 5, of the U. S. Agricultural Department:

"The temperature, for wheat, must be allowed to vary but little from 132½°, in no case rising higher than 135° or falling below 130°."

"With oats the following slight modifications are probably advantageous: (1) Have the water in the second vessel 143½° F., and immerse the seed five minutes, cooling with cold water afterwards. (2) Have the water in the second vessel at 132½° F., immerse the seed ten minutes and *do not cool* with cold water, but spread out at once to dry. This last is no doubt the best form of the Jensen treatment for oats, since it requires a shorter time than the regular method and the warmth of the grain aids it materially in drying."

"The copper sulphate treatment consists in immersing the seed in a solution made by dissolving one pound of commercial copper sulphate in 24 gallons of water for twelve hours and then putting the seed for five or ten minutes into lime water made by slacking one pound of good lime in ten gallons of water."

SUMMARY.

1. The loss occasioned by sowing seed contaminated with smut is very much greater than is usually supposed. The annual damage to the oat crop amounts to fully ten per cent. The injury to the wheat crop is much greater, the loss coming from two sources; a less yield per acre and a lower price per bushel for the damaged grain.

2. Smuts are due to the development of minute parasitic plants which grow within the tissues of the grain.

The disease is spread by spores of smut adhering to the grains before they are sown. This contamination may occur in the field through the wind carrying the spores from adjacent smutted crops, or during the threshing, or by coming in contact with any receptacle that has previously contained smutted grain. In general, experimenters believe there is little danger of contamination through spores in the soil.

3. Stinking smut attacks wheat only. Loose smuts attack all of the small grains, but that of the oat is most damaging.

4. Clean seed, or that effectually treated for smut, will produce a crop free from smut, but an adjoining smutty field may contaminate this grain for next year's crop. The only safeguard is careful treatment before planting.

5. The disease in wheat may be entirely prevented by thoroughly wetting the seed in a solution of copper sulphate, using eight ounces to a gallon of water, but this will lessen in some degree the vitality of the seed. It may also be effectually prevented, without any damage, by immersion for fifteen minutes in water raised to a temperature of 131° to 135° F.

6. Oat smut may be completely prevented by treating the seed fifteen minutes in water raised to a temperature of 132½° to 135° F. This treatment not only removes the

smut but promotes the growth and increases the yield. It may also be prevented without injury to the vitality, by immersing the seed twenty-four hours in a solution of potassium sulphide, made by dissolving one pound of the sulphide in twenty-four gallons of water.

The copper sulphate treatment, used for wheat, will effectually kill the smut in oats, but will in some degree damage the germinating power of the grain.

UNIV. OF MICH.
JAN 15 [illegible]

BULLETIN NO. 3.

MONTANA
AGRICULTURAL
EXPERIMENT STATION

PIG FEEDING.

Bozeman, Montana, June, 1894.

BOZEMAN, MONT.
THE AVANT COURIER.
1894.

46

MONTANA AGRICULTURAL

EXPERIMENT STATION.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman.
Peter Koch, Secretary and Treasurer	Bozeman.
George Kinkel, Jr., Vice-President	Manhattan.
Walter Cooper	Bozeman.
E. H. Talcott	Livingston.

EXPERIMENT STATION STAFF.

S. M. Emery	Director and Horticulturist.
Luther Foster, M. S. A.	Agriculturist and Botanist.
F. W. Traphagen, Ph. D., F. C. S.	Chemist.
W. L. Williams, V. S.	Veterinary Surgeon.
A. M. Ryon	Irrigation Engineer.

Post Office Address and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

Montana Experiment Station,
Bozeman, Montana.

NOTICE: The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Experiment Station.

Bulletin No. 3. - - - June, 1894.

PIG FEEDING.

BY LUTHER FOSTER.

The past year has made the farmers of the state realize more than ever before, the necessity of greater diversity in farm products. Many are already reducing the grain acreage and increasing the extent of meadows and other coarse forage crops and so concentrating the product of the farm into pork, beef and butter.

In the interest of such farmers, especially those engaged in pig raising, and for the encouragement of others who contemplate such a change in their farm output, this bulletin is issued.

While the principles of feeding here given apply equally to all kinds of stock, the special discussion will be confined, in the main, to the pig, leaving the questions of feeding for beef, mutton and milk production to future bulletins.

Our own Station has not been in operation a sufficient length of time for any experimental feeding, but arrangements will be completed within a few weeks for beginning a series of pig feeding experiments covering all questions of most immediate importance to the farmers of the state. The present bulletin is intended to be preliminary to this work.

The results of feeding experiments at other Stations are equally applicable in this state as far as they cover Montana foods and while, in a large portion of the state, corn cannot be included in our rations, soft wheat may be substituted for it. It will be seen farther on, both in the table of compositions and from the results of experiments in feeding, that wheat alone makes a far better balanced ration than corn and produces pork of a superior quality. Since our average yield of wheat per acre as given by the United States Agricultural Department is almost equal to the average corn yield of some of the pork growing states, it may be fed with as good results and quite as economically by the Montana farmer as can the corn by his brother farmer of the states above referred to.

As indicated above, the results given in this bulletin will be based on the feeding experiments at other Stations, including those conducted by myself at the South Dakota Station, where little corn is grown and where the chief reliances for pig foods are very similar to those of Montana.

This state at present produces a very small per cent of the hams, pork, bacon and lard consumed within her borders, one single firm having shipped in within the year 1893, over $60,000 worth of the pig product. The home grown pigs are not sufficient to supply our meat markets with the fresh pork and sausage demanded; and judging from the present outlook, all the pork likely to be produced in the state will in no way affect prices, the question with us being, not what will our pork bring in St. Paul and Chicago, but instead, at what price can they lay it down here. The Montana producer will always have in his favor the freight rates from the large market centers to the state.

FEEDING TABLES.

In order to gain a correct understanding of animal feeding, a careful study should be made of the following tables of food composition and feeding standards. These, together with their explanations, are taken from the special report of the United States Agricultural Department, on diseases of cattle and cattle feeding.

"Table I presents the studies of chemists both in this country and abroad, summarized and placed in the most available condensed form. The figures giving the composition of fodders are in most cases taken from the compilation of analyses of American fodders by Dr. E. H. Jenkins and A. L. Winton, jr., first published in Volume II of the Experiment Station Record, Department of Agriculture (pp. 702-709). That portion of the table which gives the digestible constituents was derived from the first part of the table through coefficients of digestibility given by Dr. Jenkins in the Report of the Connecticut Experiment Station for 1886 or from later sources."

WHAT THE TABLE SHOWS.

"This table looks formidable enough, but when we have studied it, column by column, I do not think it will be regarded as difficult, nor will its contents seem dry to farmer readers. In the first column are given the names of fodders, all of which are used in some portion of the country for stock-feeding purposes; next to this comes a statement of the number of analyses from which the succeeding average figures are derived.

"*Water.*—In the laboratory the scales of the chemist are so delicate that he can weigh a thimbleful of corn meal with a smaller proportional error than the farmer weighs a wagon load of corn. In a small dish on these scales he places a sample of the fodder with which he is to work and determines its weight. Placing this in an oven it is dried at a temperature of 212° F. for several hours and weighed again. The heat has driven off the water and the difference in the two weights represents the water which the sample contained. The average amount of water found in the various samples in the list is placed in the column headed

"Water." It will be seen that the proportion of water in the different feed stuffs varies greatly. In 100 pounds of pasture grass there are 75.3 pounds of water on an average; with roots the amount reaches as high as 90 pounds, while for straw and grain it varies from 8 to 16 pounds of water per hundred weight. Water is the great vehicle for transporting food both in the plant and animal and while of the highest importance to both, it is so universal and abundant that we need not further consider it at this time.

"*Ash.*—Carefully burning a sample of the fodder, the chemist determines the ash. By the table we find that in 100 pounds of pasture grass there are 2.5 pounds ash, while in clover hay there are over 6 pounds. One hundred pounds of shelled corn contains only 1.5 pounds of ash, while the same weight of wheat bran yields over 5 pounds. The ash elements in plants are very important, since they enter into the composition of all the tissues of the body in a small way, and form the larger part of the bones. Experience shows that when the stockman feeds his animals abundantly with a variety of nutritious foods they are amply supplied with ash for all necessities of the body, so that as with water this part of the plant substance need not receive special attention when considering the constituents of feeds, though there are a few special cases where the supply of ash is apt to be lacking, even when the animals are seemingly well nourished.

"*Crude protein* marks a very important group of substances in fodders, the characteristic element of all being nitrogen. The chemist has found that protein compounds weigh 6.25 times as much as the nitrogen contained; by a complicated process he determines the weight of nitrogen in a sample of feed and multiplies this by 6.25, which gives the crude protein. A considerable portion of the bones, the ligaments which hold the bones together, the muscles which surround the bones, the tendons which bind the muscles to the bone, and the great nervous system, as well as the internal organs of the body, are largely composed of protein compounds. From this we can readily understand that protein is a very important part of stock foods, being especially needed with young, growing animals. We turn with interest to the table and note that the total crude protein in pasture grass is 4 pounds to the hundred, while in oats there are 11.8 pounds, in corn, 10.5 pounds, and nearly 33 pounds in 100 of linseed meal.

"*Crude fiber* is determined by boiling a sample of the fodder, first with a weak alkali, and then with a weak acid in order to dissolve out as much of the substance as possible. The undissolved portions represent the tougher parts of the framework of the plant, usually termed cellulose or crude fiber. The table shows that a large portion of rye straw is crude fiber, while in grains like corn or wheat the amount is very small.

"*Ether Extract.*—On another sample of the fodder the chemist places ether, which dissolves out whatever fats and wax it contains, and this dissolved portion is called the ether extract or crude fat. Hay and straw contain very little fat, and still less is found in mangolds or turnips, while corn contains considerable, and oil meal and cottonseed meal a relatively large amount.

"*Nitrogen-free extract* signifies what is left of the organic matter of the plant after deducting the preceding groups of elements. It contains starch, sugar, dextrine and gums.

"*Carbohydrates.*—The nitrogen-free extract and the crude fiber are grouped together under the term carbohydrates. The leading function of the carbohydrates is to furnish fuel for the animal body. Portions not needed for immediate wants may be converted into fat and stored up in the tissues awaiting future demands.

"The figures given in all the columns of the table we have passed over are derived from analyses in the laboratory, and represent the total amount of each of the plant constituents in the several groups. Thus far the investigation is purely a chemical one, though the grouping of the substances has some relation to the uses of the food in the animal system.

Having learned the amount of each of the constituents in a given fodder, the chemist proceeds to feed it to some farm animal, usually an ox or a sheep, in order to ascertain what portion of each is digestible. The value of gold ore is not rated by the total amount of gold contained, but rather by that portion which can be recovered by practical processes; so with our feeds, only those portions which can be digested and utilized by the animal are really valuable. The results of digestion trials are grouped in the last columns of the table under the head "Per cent of digestible matter," and these data have cost the chemist and animal physiologist much patient labor; even now the results are crude and far from satisfactory.

"Let us study this table item by item, as we did the first part. We learn that while the crude protein in pasture grass is 4 in 100 pounds, the digestible crude protein is 2.8 pounds in a hundred weight. The digestible carbohydrates, the compounds of crude fiber and nitrogen-free extract are 12.3 pounds, and the digestible ether extract 0.6 pounds. The chemist has found that a pound of fat will give about 2.2 times as much heat as a pound of carbohydrates. Since the fats serve the same purpose in the body as the carbohydrates, we can reduce the fat found in a fodder to a carbohydrate equivalent by multiplying it by 2.2. To obtain the nutritive ratio expressed in the last column of the table, the digestible fat is multiplied by 2.2 and added to the digestible carbohydrates, and the sum divided by the digestible protein. The nutritive ratio of pasture grass is 1: 4.9; that is, for every pound of digestible protein in pasture grass there are 4.9 pounds of digestible carbohydrates and carbohydrate equivalents. The following table summarizes the results of analyses in digestion trials as just explained:

Table I.--Average Composition of American Feeding Stuffs.

Feeding stuffs.	Number of analyses.	Percentage composition.						Per cent digestible matter			Nutritive ratio.
		Water.	Ash.	Crude protein.	Crude fiber.	Nitrogen-free ex't.	Ether extract	Crude protein.	Carbohydrates.	Ether extract	
Green fodders and silage.											
Pasture grass	10	75.3	2.5	4.0	5.9	11.4	.9	2.8	12.3	.6	1:4.9
Red top (Agrostis vulgaris) in bloom	5	65.3	2.3	2.8	11.0	17.7	.9	2.0	20.5	.6	1:10.9
Orchard grass (Dactylis glomerata) in bloom	4	73.0	2.0	2.6	9.4	15.8	.9	1.8	18.1	.6	1:10.8
Kentucky blue grass (Poa pratensis)	18	65.1	2.8	4.1	9.1	17.6	1.3	2.9	19.2	.8	1:7.2
Timothy (Phleum pratense)	56	61.6	2.1	3.1	11.8	20.2	1.2	1.9	21.9	.7	1:12.3
Maize (corn) fodder:											
Flint varieties	40	79.8	1.1	2.0	4.3	12.1	.7	1.5	12.0	.5	1:8.7
Dent varieties	63	79.0	1.2	1.7	5.6	12.0	.5	1.2	12.8	.4	1:11.8
Sweet varieties	21	79.1	1.3	1.9	4.4	12.8	.5	1.4	12.6	.4	1:9.6
Red clover	43	70.8	2.1	4.4	8.1	13.5	1.1	2.9	14.1	.7	1:5.4
Alsike clover in bloom	4	74.8	2.0	3.9	7.4	11.0	.9	2.5	11.1	.5	1:4.9
Alfalfa (lucerne)	23	71.8	2.7	4.8	7.4	12.3	1.0	3.6	11.4	.4	1:3.4
Cowpea	10	83.6	1.7	2.4	4.8	7.1	.4	1.3	7.7	.2	1:6.3
Sorghum (whole plant)	11	79.4	1.1	1.3	6.1	11.6	.5	.8	12.7	.4	1:17.0
Rye fodder	7	76.6	1.8	2.6	11.6	6.8	.6	2.1	14.1	.4	1:7.1
Oat fodder	5	62.2	2.5	3.4	11.2	19.3	1.4	2.7	22.7	1.0	1:9.2
Corn silage	99	79.1	1.4	1.7	6.0	11.1	.8	1.2	11.8	.6	1:10.9
Sorghum silage	6	76.1	1.1	.8	6.4	15.3	.3	.6	14.9	.2	1:25.6
Red clover silage	5	72.0	2.6	4.2	8.4	11.6	1.2	2.2	10.0	.5	1:5.0
Hay and dry coarse fodders.											
Corn (maize) fodder, field cured	35	42.2	2.7	4.5	14.3	34.7	1.6	2.8	29.5	1.0	1:11.3
Corn (maize) stover, field cured	60	40.5	3.4	3.8	19.7	31.5	1.1	2.0	34.1	.6	1:17.7
Hay from mixed meadow grasses	11	16.0	4.6	6.4	29.9	41.0	2.1	3.6	42.7	1.0	1:12.5
Timothy hay	68	13.2	4.4	5.9	29.0	45.0	2.5	3.0	43.9	1.2	1:15.5
Hay from Hungarian grass	12	7.7	6.0	7.5	27.7	49.0	2.1	4.5	46.4	1.0	1:10.8
Red clover hay	38	15.8	6.2	12.3	24.8	38.1	3.3	6.5	34.9	1.6	1:5.9
Alsike hay	9	9.7	8.3	12.8	25.6	40.7	2.9	6.8	36.9	1.4	1:5.9
Alfalfa hay	21	8.4	7.4	14.3	25.0	42.7	2.7	7.6	37.8	1.3	1:5.4
Cowpea hay	8	10.7	7.5	16.6	20.1	42.2	2.9	8.1	37.3	1.7	1:5.1
Wheat straw	7	9.6	4.2	3.4	38.1	43.4	1.3	.6	38.3	.5	1:65.7
Rye straw	7	7.1	3.2	3.0	38.9	46.6	1.2	.6	40.6	.4	1:69.1
Oat straw	12	9.2	5.1	4.0	37.0	42.4	2.3	1.6	41.7	.7	1:27.0
Roots and tubers.											
Mangels	9	90.9	1.1	1.4	.9	5.5	.2	1.1	4.8	....	1:4.4
Rutabagas	4	88.6	1.2	1.2	1.3	7.5	.2	.9	7.1	....	1:8.9
Turnips	3	90.5	.8	1.1	1.2	6.2	.2	.6	5.5	....	1:9.2

Table I.--Average Composition of American Feeding Stuffs--Continued.

Feeding Stuffs.	Number of analyses.	Percentage Composition.						Per cent digestible matter.			Nutritive ratio.
		Water.	Ash.	Crude protein.	Crude fiber.	Nitrogen free ex't.	Ether extract	Crude protein.	Carbohydrates.	Ether extract	
Roots and Tubers.—Continued											
Red beets	9	88.5	1.0	1.5	.9	8.0	.1	.9	7.6	....	1.8.4
Sugar beets	19	86.5	.9	1.8	.9	9.8	.1	1.1	9.3	....	1:8.5
Carrots	8	88.6	1.0	1.1	1.3	7.6	.4	1.0	7.1	....	1:7.1
Potatoes	12	78.9	1.0	2.1	.6	17.3	.1	1.4	16.1	....	1:11.5
Grains and other seeds.											
Corn (maize):											
Dent	86	10.6	1.5	10.3	2.2	70.4	5.0	7.0	68.4	3.9	1:10.8
Flint	68	11.3	1.4	10.5	1.7	70.1	5.0	7.1	68.0	3.9	1:10.1
Sweet	26	8.8	1.9	11.6	2.8	66.8	8.1	7.9	61.4	6.3	1:9.7
Average for all varieties and analyses	208	10.9	1.5	10.5	2.1	69.6	5.4	7.1	62.7	4.2	1:10.1
Wheat, spring varieties	13	10.4	1.9	12.5	1.8	71.2	2.2	9.8	55.3	1.8	1:6.[illegible]
Winter varieties	262	10.5	1.8	11.8	1.8	72.0	2.1	9.2	58.9	1.8	1:6.5
Average for all varieties and analyses	310	10.5	1.8	11.9	1.8	71.9	2.1	9.3	58.8	1.8	1:6.4
Barley	10	10.9	2.4	12.4	2.7	69.8	1.8	9.5	66.1	1.2	1:7.2
Rye	6	11.6	1.9	10.6	1.7	72.5	1.7	8.3	65.5	1.2	1:8.3
Oats	30	11.0	3.0	11.8	9.5	59.7	5.0	9.1	44.7	4.1	1:5.9
Buckwheat	8	12.6	2.0	10.0	8.7	64.7	2.2	7.7	49.2	1.8	1:6.9
Peas	2	10.5	2.6	20.2	14.4	51.1	1.2	18.0	56.0	.9	1:3.2
Cowpea	5	14.8	3.2	20.8	4.1	55.7	1.4	18.1	34.5	1.3	1:2.1
Flaxseed, ground	2	8.1	4.7	21.6	7.3	27.9	30.4	18.5	26.0	27.1	1:4.7
Mill products and refuse feeds.											
Corn (maize) meal, bolted	77	15.0	1.4	9.2	1.9	68.7	3.8	6.3	61.8	3.0	1:11.0
Corn and cob meal	7	15.1	1.4	8.5	6.6	64.8	3.5	6.5	56.3	2.9	1:9.6
Corncob	18	10.7	1.4	2.4	30.1	54.9	.5	1.6	48.9	.3	1:27.8
Corn bran	2	10.9	1.7	9.4	4.8	67.3	5.9	6.2	50.9	3.4	1:9.4
Wheat bran from roller mills	7	12.0	5.6	16.1	8.4	53.7	4.2	12.6	44.1	2.9	1:4.0
Wheat bran, old process	9	12.0	4.9	13.0	8.1	58.2	3.8	10.1	47.5	2.6	1:5.3
Wheat bran, all analyses	88	11.9	5.8	15.4	9.0	53.9	4.0	12.0	44.5	2.8	1:4.2
Wheat shorts	12	11.8	4.6	14.9	7.4	56.8	4.5	11.6	45.4	3.2	1:4.5
Wheat middlings	33	12.1	3.4	15.7	4.7	60.2	4.0	12.2	47.2	2.9	1:4.4
Wheat screenings	10	11.6	2.9	12.5	4.9	65.1	3.0	9.8	51.0	2.2	1:5.7
Barley meal	3	11.9	2.6	10.5	6.5	66.3	2.2	8.1	57.7	2.2	1:7.7
Rye bran	7	11.6	3.6	14.7	3.5	63.8	2.8	9.7	48.0	1.6	1:5.3
Rye shorts	1	9.8	4.9	18.0	5.1	59.9	2.8	11.9	45.1	1.6	1:4.1

Oatmeal	6	7.9	2.0	14.7	.9	67.4	7.1	11.3	49.9	5.8	1:5.5
Oat shorts	1	5.5	3.9	18.1	8.9	57.3	6.2	14.1	46.2	4.5	1:4.0
Oat dust	2	6.7	6.9	13.5	18.2	50.2	4.8	8.9	38.4	2.8	1:5.0
Oat feed	4	7.7	3.7	16.0	6.1	59.4	7.1	12.5	47.0	5.0	1:4.6
Buckwheat bran	2	10.5	3.0	12.4	31.9	38.8	3.3	7.4	30.4	1.9	1:4.7
Buckwheat shorts	2	11.1	5.1	27.1	8.3	40.8	7.6	21.1	33.5	5.5	1:2.2
Buckwheat middlings	6	12.7	5.1	28.2	4.2	42.3	7.5	22.0	33.4	5.4	1:2.1
Malt sprouts	5	9.6	5.9	24.8	11.0	47.0	1.7	19.8	36.2	1.7	1:2.1
Brewers' grains	15	75.7	1.0	5.4	3.8	12.5	1.6	3.9	9.5	1.3	1:3.2
Brewers' grains, dried	5	7.7	3.6	22.2	12.3	47.9	6.3	16.2	35.5	5.3	1:2.9
Germ meal	8	8.6	1.0	10.9	10.2	64.0	5.4	9.3	68.6	4.1	1:7.8
Gluten meal	32	9.6	.7	29.4	1.6	52.5	7.4	25.0	49.4	5.6	1:2.5
Starch feed wet	12	65.4	.3	6.1	3.1	22.0	3.1	5.1	21.7	2.4	1:5.3
Hominy feed	12	11.1	2.5	9.8	3.8	64.5	8.3	8.3	61.9	6.3	1:9.1
Cotton-seed meal	37	8.2	7.2	42.4	5.6	23.8	12.9	36.9	18.1	12.3	1:1.2
Linseed meal, old process	21	9.2	5.7	32.9	8.9	35.4	7.9	28.3	32.2	7.1	1:1.7
Linseed meal, new process	14	10.1	5.8	33.2	9.5	38.4	3.0	27.2	31.8	2.7	1:1.4
Apple pomace	7	76.7	.5	1.4	3.9	16.2	1.3	1.0	17.2	.9	1:19.2
Dried blood	3	8.5	4.7	84.4	....	....	2.5	59.1	......	2.3	1:0.1
Meat scraps	144	10.7	4.1	71.2	....	.3	13.7	68.4	.3	13.5	1:0.4
New milk from cows	793	87.2	.7	3.6	....	4.9	3.7	3.5	4.8	3.7	1:3.7
New milk from goats	38	85.7	.8	4.3	....	4.5	4.8	4.2	4.4	4.8	1:3.6
New milk from ewes	33	80.8	.9	6.5	....	4.9	6.9	6.4	4.8	6.9	1:3.1
New milk from mares	47	90.8	.4	2.0	....	5.7	1.2	2.0	5.5	1.2	1:4.1
New milk from sows	7	84.6	1.1	6.4	....	3.2	4.8	6.3	3.1	4.8	1:2.2
Skimmed milk	96	90.4	.7	3.3	....	4.7	.9	3.1	4.7	.8	1:2.1
Skimmed milk, centrifugal	7	90.6	.7	3.1	....	5.3	.3	2.9	5.2	.3	1:2.0
Buttermilk	85	90.1	.7	4.0	....	4.0	1.1	3.9	4.0	1.1	1:1.7
Whey	46	93.4	.7	.9	....	4.8	.3	.8	4.7	.3	1:6.7

"Before passing to the next division of the subject, let us review briefly how animals grow and live. All animals live directly or indirectly on foods furnished by plants. The plant grows through the union of chemical compounds taken from the air and soil and brought up into its structure, through that mysterious principle called life, by the energy of the sun. The sun pouring its rays day after day in summer time, furnishes the energy which welds the simpler compounds into the more complex ones of the plant organism. In summer time our animals crop the grasses of the fields, and in the fall man gathers plants and their seeds into barns and storehouses that in winter time he may pass them over to his farm animals for sustenance and growth. The compounds in the plant substance are separated in the laboratory of the stomach and digestive tract and carried about the body, where they are built up into the body tissues or stored up as fat, or they may be burned up at once if needed to give out energy and warmth. Dr. Armsby has happily used the figure of a coiled spring to illustrate this wonderful phenomenon. The energy of the sun in summer time winds up the spring in the plant, and when the animal consumes the plant the spring is unwound and exhibits just as much energy in the unwinding as was used in winding it up.

"In studying these plant compounds we have divided those which need especial attention into three groups, under the heads protein, carbohydrates and fat. As already shown, the protein compounds are that portion of the food material which may go to build up the muscular portion of the animal body. Among the list of food articles used by man rich in protein are the lean part of meat, the white of egg, the cheese of milk and the gluten of wheat; of stock foods rich in protein we have cotton-seed meal, oil meal, peas, wheat bran, clover and alfalfa hay. The first great use of protein is in building up the muscular portion of the body, but we should not forget that it also gives off heat and energy in being broken down to simpler compounds, and may also be converted into fat and stored up in the tissues of the body for future use.

"Since the carbohydrates contain no nitrogen they can not go to build up the muscular portion of the body, but nevertheless they are of great importance and form the largest part of foods used by our farm animals. The first great use of carbohydrates is to furnish fuel for warming the body and enabling it to perform work. Of human foods rich in carbohydrates we have sugar and starch, both almost chemically pure, while the grain of wheat and corn are both very rich in carbohydrates. In animal foods corn, oat straw and cornstalks are all rich in carbohydrates. As the protein compounds may be called the muscle-formers, so the carbohydrates may be called the fuel or energy givers of the body. The fats in foods serve the same purpose as the carbohydrates, but are more potent, giving off more heat in burning. A pound of fat is generally regarded as 2.2 times as valuable as a pound of sugar or starch in food.

AMOUNT OF NUTRIENTS REQUIRED BY OUR FARM ANIMALS.

"The next step in our study is to ascertain the amount of the several constituents in feeding materials required by different farm animals under varying conditions of maintenance, growth and fattening. Since the weights of our animals vary according to age and breed it is well to take some simple standard of weight, and for convenience it has been placed at a thousand pounds. The needs of growing animals differ from those that are mature, and the requirements of work animals are not the same as those at rest or taking on fat. In Table II is summarized the amount of digestible nutrients required by a thousand pounds, live weight, of farm animals.

"To study this table let us take the first case—that of an ox at rest in his stall. This ox is supposed to weigh 1,000 pounds, and to be kept perfectly comfortable as to temperature and environment, and to do no work, neither gaining nor losing in weight. The amount of food required under these conditions will be the minimum for such an animal, of course. It will be found when we have furnished this ox with the digestible nutrients required that the total organic substance, which is the weight of the fodder, less the water and ash it contains, will amount to 17.5 pounds. Every beat of the heart, every respiration, the tension of the muscles while standing, all mean wear and destruction of muscular tissue. Indeed, every manifestation of life means the consumption of food to repair the waste of some portion of the body. The Germans have held that 0.7 of a pound of crude protein is necessary to make good this loss. For warming the body and running its machinery, if we may so speak, there are required 8 pounds of digestible carbohydrates and 0.15 pounds of ether extract. Adding the digestible protein, carbohydrates and ether extract together, we get a total of 8.85 pounds of total nutritive substance. If we multiply the digestible ether extract by 2.2 and add it to the digestible carbohydrates the sum is 8.33, which, divided by 0.7, gives a quotient of 12 in round numbers. That is, for every 1 pound of crude protein required by the ox, he needs 12 pounds of digestible carbohydrates or their equivalents in fat. Investigation by several American experimenters have shown that the amount of nutrients stated by the Germans as only sufficient to maintain a thousand-pound ox is more than sufficient for that purpose under our conditions, and that the ox will make a small gain therefrom. Our work, however, has not progressed far enough to reconstruct even this portion of the table, so that we shall have to let it stand as stated by the Germans.

"In the same table we learn that the ox heavily worked requires 2.4 pounds of digestible protein per day, or three times as much as when at rest. We are not surprised at this, for when performing labor the muscles must be worn down much more rapidly than when an animal is idle. A milch cow of the same weight requires more protein and almost as much carbohydrates as the heavily worked ox. Though there is little tax on the muscles, yet a large amount of protein is needed for the cheese portion of the milk. To elaborate this, as well as the sugar and fat, makes a heavy demand for food by the dairy cow.

"Table II is compiled by the German scientist, Dr. Emil Wolff, and gives the amount of digestible substances he considers necessary by our farm animals:

Table II.--Feeding Standards (According to Wolff.)

[Per day and per 1000 pounds, live weight.]

Animals, etc.		Total organic substance.	Nutritive (digestible) substances.			Total nutritive substances.	Nutritive ratio.
			Crude protein.	Carbohydrates.	Ether extract.		
		Pounds	Pounds.	Pounds.	Pounds	Pounds.	
1. oxen at rest in stall....		17.5	0.7	8.0	0.15	8.85	1:12.0
2 Wool sheep, coarser breeds		20.0	1.2	10.3	0.20	11.70	1:9.0
Wool sheep, finer breeds.		22.5	1.5	11.4	0.25	13.15	1:8.0
3. Oxen moderately worked		24.0	1.6	11.3	0 30	13.20	1;7.5
Oxen heavily worked.....		28.0	2.4	13.2	0.50	16.10	1:6 0
4. Horses moderately worked		21.0	1 6	10.0	0.50	12.10	1:7.0
Horses heavily worked....		23.0	2.5	12.1	0.70	15.30	1:5.5
5. Milch cows................		24.0	2.5	12.5	0.40	15.40	1:5.4
6. Fattening oxen, 1st period		27.0	2.5	15 0	0.50	18.00	1:6.5
Fattening oxen, 2nd period		26.0	3.0	14.8	0.70	18.30	1:5.5
Fattening oxen, 3rd period		25.0	2 7	14.8	0.60	18.10	1:6.0
7. Fattening sheep, 1st period		26 0	3.0	15.2	0 50	18.70	1:5.5
Fattening sheep, 2nd period		23.0	3.5	14.4	0.60	18.50	1:4.5
8. Fattening swine, 1st period		36 0	5.0	27.5		32.50	1:5.5
Fattening swine, 2nd period		31.0	4 0	24.0		28.00	1:6 0
Fattening swine, 3rd period		23.5	2.7	17.5		20.20	1:6.5
9 Growing cattle:							
Age, months.	Average live weight per head.						
2–3	165 lbs	22.0	4.0	13.8	2.0	19.8	1:4.7
3–6	330 lbs..	23.4	3.2	13 5	1.0	17.7	1:5.0
6–12	550 lbs..	24.0	2.5	13.5	0.6	16.6	1:6.0
12–18	770 lbs..	24.0	2.0	13.0	0.4	15.4	1:7.0
18–24	940 lbs	24.0	1.6	12 0	0 3	13.9	1:8.0
10. Growing sheep:							
5–6	62 lbs .	28.0	3.2	15.6	0.8	19.6	1:5.5
6–8	73 lbs.	25.0	2.7	13.3	0.6	16.6	1 5.5
8–11	84 lbs..	23 0	2.1	11 4	0.5	14 0	1:6 0
11–15	90 lbs.	22.5	1 7	10.9	0 4	13.0	1:7.0
15–20	95 lbs..	22.0	1.4	10.4	0.3	12.1	1:8.0
11 Growing fat pigs:							
2–3	55 lbs..	42 0	7.5	30.0		37 5	1:4.0
3–5	110 lbs..	34.0	5.0	25.0		30.0	1:5.0
5–6	137 lbs..	31.5	4.3	23.7		28.0	1:5.0
6–8	187 lbs..	27.0	3.4	20.4		23.8	1:6.0
8–12	275 lbs..	21.0	2.5	16.2		18.7	1:6.5

"From Tables I and II we are now in position to calculate a ration for a fattening steer or a dairy cow. Let us form a ration for a dairy cow weighing 1,000 pounds and yielding a full flow of milk. Suppose we have at hand the following common feeding stuffs: corn fodder, clover hay, bran, corn meal and cotton-seed meal. By the last table we find the requirements for a cow weighing 1,000 pounds to be 2.5 pounds digestible protein; 12.5 pounds digestible carbohydrates and 0.4 pound digestible ether extract.

"We place these amounts at the head of our table at A:

Table III--Showing How to Construct a Ration for a Dairy Cow.

	Nature and weight of feed.	Organic matter.	Digestable.		
			Protein.	Carbohydrates.	Ether extract.
		Pounds.	Pounds.	Pounds.	Pounds
A.	Required by standard	24.0	2.5	12.5	0.4
B.	14 pounds foddder corn	7.71	0.39	4.13	0.14
	6 pounds clover hay	4.71	0.39	2.69	0.10
	5 pounds roller bran	4.12	0.63	2.20	0.15
	5 pounds ground corn	4.38	0.36	3.14	0.21
C.	First trial ration	20.92	1.77	11.56	0.60
	2 pounds cotton-seed meal	1.69	0.74	0.36	0.25
	Second trial ration	22.61	2.51	11.92	0.85

"In order to properly distend the rumen the feed should have a certain bulk, and will amount on the average to about 24 pounds of organic matter, which sum we place in the first column. This portion of the table can vary more than any other without serious detriment. Having the requirements before us in the table, let us approximate it by combining several food materials from our list. For trial we will take 14 pounds of corn fodder. By adding the water given in Table I to the ash and subtracting from 100, we have the total organic matter in 100 pounds of fodder corn. For 14 pounds of fodder corn the amount of organic matter is 7.71, which we place under the column headed "Organic Matter." By Table I, again, we learn that the digestible crude protein of field-cured fodder corn is 2.8 per 100 pounds; for 14 pounds it is 0.39. The digestible carbohydrates in the fodder corn is 29.5 for 100 pounds, and for 14 pounds 4.13. The ether extract in 100 pounds of fodder corn is 1 pound, and in 14 pounds is 0.14. We place these sums in their respective columns, which gives the total organic matter and digestible material for 14 pounds of fodder corn. In the same manner we find the organic matter and digestible nutrients in 6 pounds of clover hay, then in 5 pounds of bran, and finally 5 pounds of ground corn, all of which is summarized under B of the table. We next add the several columns to ascertain the total constituents. The sums are found under the first trial ration. We now compare this trial ration, which is the sum of the items under B, with the required ration at A. We notice that the organic matter is a little more than 3 pounds short of the requirements, and there is still about three-fourths of a pound of protein and a pound of carbohydrates lacking. while the ether extract is already 0.2 of a pound in excess. Our ration is short of the requirements, and to bring B still nearer A we add to the trial ration as given, 2 pounds of cotton-seed meal, choosing this feed, because we must add some substance rich in protein. Determining the nutrients in 2 pounds of cotton seed meal we place them at C, and adding the items to the first trial ration, or B, we get the second trial ration. In the second trial ration we observe that the organic matter is 1.31 pounds short of the requirements, the protein .01 of a pound in excess, the carbohydrates 0.58 of a pound short while ether extract is 0.45 pound in excess of requirements. We have learned that the ether extract is worth 2.2 times as much as the same weight of carbohydrates. We multiply the excess, 0.45 by 2.2 and find that the excess is equal to 0.99 of a pound of carbohydrates. This sum brings the carbohydrates above the required standard. Our second trial ration is, therefore, slightly lacking in organic matter, but contains the full amount of protein required and a slight excess of carbohydrates or their equivalents. We find the nutritive ratio of this ration by multiplying the ether extract 0.85 by 2.2, adding it to the carbohydrates and dividing by 2.51, and obtain the nutritive ratio of 1:5.5, or about the requirements given in Table II. This is as close as we can expect to work in practice.

"Having studied this problem over carefully, the student is in position to use Tables I and II in a study of the requirements of his stock and the feeds he has at hand. With a little patience feed combinations can be made which will conform to the requirements. I have gone over this problem carefully in order to show just how the tables are used. The student can select from the first table such feed stuffs as he has at hand or can secure, and from these construct rations to meet the wants of his particular case. The exercise will prove not only interesting, but profitable, for it will throw much light on the proper combinations of food to best meet the wants of our farm animals."

MONTANA FOODS.

From the table of compositions it may be seen that our Montana foods are of the very best for meat production. Field peas, wheat, oats, barley, rye, alfalfa and clover, all contain a large per cent. of the nutrients required for the most healthful and vigorous growth of bone and muscle. Those containing relatively the greatest quantity of protein, such as peas and alfalfa, should be fed to the young, growing animal, reserving the wheat, barley, etc., which contain more of the heat and fat producing nutrients, for the last half of the feeding period.

While most of these foods have been thoroughly tested for feeding, there has been but little done in this line experimentally with wheat, but in nearly all cases where tried, the result for pork production has been favorable. Prof. French, of the Oregon Station, in speaking of the quality of wheat fed pork, says: "The fat is very heavy and thick and it is very firm in texture. The lean meat is very juicy and light in color, which characteristic has marked all of the results in feeding wheat to pigs thus far carried on at our Station. In short, the quality of the meat is all that could be desired." He further says: "The results are such as to dispel all doubts from the minds of those who have thought that wheat could not be made to produce pork equal in quality to that corn fed. The pigs at the time of slaughtering were 8½ months old and the average live weight was 306.8 pounds. This fact is mentioned for the purpose of inducing more interest if possible in the matter of early maturity. What might be profit is complete loss many times, in feeding animals which have been grown or allowed to come up and then fattened. Proper care and feeding should begin before the animal is born and continue until it has reached the shambles."

The following quotation from a recent bulletin of the South Dakota Station giving the results of a single experiment adds strength to the Oregon report as to the superior quality of wheat fed pork:

"The grain for each of the several lots was soaked in cold water. Each lot was provided with a separate tub in which enough grain to last for several days was placed, and enough water was added to not only thoroughly moisten the grain, but to furnish all the water needed by the hog. From time to time more grain and water was added as occasion required. An accurate record was kept of the weight of all grain put into the tubs and the supply was so regulated that they would be emptied at the expiration of each period.

"Lot I was fed entirely upon Canada field peas, unground.

"Lot II was fed on spring wheat of rather poor quality, unground.

"Lot III was fed upon Dakota grown Dent corn, ground.

"Lot IV was fed upon spring wheat, same quality as that fed to lot II, ground.

"The pigs were all given all the food they could be induced to eat.

RESULTS.

"1. Hogs, averaging about 100 lbs in weight, can be purchased near Sept. 1st at $4.50 per hundred live weight, fed three months on nothing but wheat, water, ashes and salt, and an occasional handful of hay or corn fodder, butchered and sold Dec. 1st for $5.50 per hundred dressed; and will return from 56 to 58 cents per bushel for wheat consumed, without allowing anything for manure, or labor in caring for hogs.

"2. At present prices wheat can be profitably fed as an entire ration, but it would undoubtedly pay better to mix it with some other food, particularly during the earlier stages of fattening.

"3. Hogs fed on ground wheat made a more rapid and uniform gain, and produced pork of rather nicer quality; but they also consumed more food than those fed upon whole wheat. Those fed ground wheat required 4.81 pounds of wheat to produce one pound of gain, while those fed whole wheat required 4.91 pounds to make the same gain. Ground wheat brought 58.39 cents per bushel, while that fed whole brought 55.83 cents per bushel, a difference of only 2.56 cents per bushel. This would hardly pay for grinding, but considering the better quality of the pork and greater weight, it would probably pay to grind, if it could be done without much extra cost.

"4. Ground wheat brought 58.39 cents, whole wheat 55.83 cents, peas 65.36 cents, and corn 60 cents per bushel, on an average, for all the grain consumed during the entire experiment, continuing for 90 days. Hogs fed on peas did much better, in proportion, during the first part of the experiment than they did during the latter part, which would indicate that peas are not as good for a complete ration for a long period as either wheat or corn.

"5. The quality of the pork made from corn and ground wheat was about equal, and was superior to that made from whole wheat, peas or mixed food. That made from mixed food was the fattest.

"6. The average daily gain of hogs fed on peas was 1.21 pounds, on whole wheat 1.12 pounds, on ground corn 1.40 pounds, on ground wheat 1.32 pounds; and on mixed foods 1.61 pounds.

"7. The question, when should fattening begin and how long should it continue, was not settled, but it was very plainly demonstrated that a considerably larger return per bushel for food consumed would have been realized if the hogs had been sold at the end of the second period. This was particularly true of lot I, fed on peas. The decrease in rate of gain in proportion to food consumption for those fed cornmeal and wheat was no greater than could be accounted for by the natural result of increased weight and age."

Numerous un-official experiments made by farmers of different states all tend to show that wheat not only produces the finest quality of pork but also that it can be fed economically. The American Farmer says: "Wheat-fed pork is as superior to corn-fed pork as the latter is superior to the village slop fed porker."

Ohio and Indiana farmers have been making pork of their winter wheat for several years. Some claim that 20 pounds live weight can be made from a bushel of wheat, but this is no doubt under special conditions for short periods. Lean pigs, such as would result from running in pastures with a small allowance of grain until four or five months old, gain very rapidly when a full grain ration is added. We cannot reasonably expect more than 15 pounds gain from each bushel of wheat, averaging through the whole feeding period. Greater gains may result in the early part of the feeding with young pigs, but as maturity approaches—the end of the feeding period—more food is required for a pound of gain and no doubt some what less than 15 pounds of pork would result from feeding a bushel of wheat.

The following, relating to the general feeding value of wheat, is taken from a recent circular of information issued by the United States Agricultural Department on "Wheat as a Food for Growing and Fattening Animals:"

"It is seen that wheat contains practically the same amount of protein per 100 pounds as oats, and that both wheat and oats contain about 30 per cent more protein than corn. On the other hand, wheat only has about one-half as much fatty matter as corn and oats. In carbohydrates the position of wheat is about halfway between that of corn and oats.

"Protein, that is the albuminoid constituents of grain, goes to build up the albuminoid tissues of the animal body of which the muscles are the most prominent part, but it may also be changed into fat. The fat in the animal body comes, therefore, both from the fat and the protein in the food which is eaten. The carbohydrates sustain the heat of the body and must be present in sufficient quantity or the more valuable fat which has already been assimilated will be used for this purpose. Young growing animals require more protein than older ones, and also more than fattening animals, in order to supply material for building up the muscles, tendons, and other albuminoid structures.

"We must not conclude from these facts, as some have, that because wheat is particularly indicated for young growing animals it is not adapted for those which are fattening. The fallacy of such a conclusion is shown by the following comparisons:

	Protein.	Carbohydrates.	Fat.	Nutritive ratio.
First comparison.				
Feeding standard:				
Growing cattle, 6 to 12 months old	2.5	13.5	1.6	1:6.0
26.6 pounds wheat	2.5	15.0	0.5	1:6.4
Second comparison.				
Feeding standard:				
Fattening cattle, second period	3.0	14.8	0.7	1:5.5
33⅓ pounds wheat	3.1	18.6	0.6	1:6.4
33⅓ pounds corn	2.4	20.9	1.4	1:10.1

"This table brings out in the clearest possible manner, first, the near approach chemically of 26.6 pounds of wheat to the German standard ration for growing cattle from 6 to

12 months of age, and, secondly, the fact that 33⅓ pounds of wheat comes much nearer the feeding standard for fattening cattle than does the same quantity of corn. The proportion of the protein to carbohydrates and to fat is very much nearer the standard in wheat than in corn. Tried by these standards wheat is better both for growing and fattening animals than is corn.

"These standards, however, are not to be considered as perfect. Corn comes nearer being an ideal grain for fattening animals in this country than is indicated by the tables. Such animals apparently do not need as much protein as is contained in the standard, and may take with advantage more carbohydrates and fat. Equal parts of wheat and corn should, therefore, prove better for fattening animals than either of these grains alone. For growing animals corn is plainly not so suitable as is wheat or oats.

"When wheat and corn are the same price per bushel, it is preferable to feed wheat and sell corn. First, because wheat weighs 7 per cent heavier per bushel than corn; secondly, because wheat is weight for weight an equally good grain for fattening animals, and better for growing animals; and thirdly, because there is much less value in fertilizing elements removed from the farm in corn than in wheat.

"There are certain points to be borne in mind when one is commencing to feed wheat. Our domesticated animals are all very fond of it, but are not accustomed to eating it. Precautions should consequently be observed to prevent accidents and disease from its use. It is a matter of common observation that when full-fed horses are changed from old to new oats they are liable to attacks of indigestion, colic, and founder. If such results follow the change from old to new oats, how much more likely are they to follow a radical change, such as that from oats to wheat? For this reason wheat should at first be fed in small quantities. It should, when possible, be mixed with some other grain, and care should be taken to prevent any one animal from getting more than the quantity intended for it.

"These precautions are especially necessary when wheat is fed to horses, as these animals are peculiarly liable to colic and other disturbances of the digestive organs, accompanied or followed by laminitis. Cattle, sheep and hogs frequently crowd each other from the feeding troughs, in which case some individuals obtain more than their share, and may bring on serious or fatal attacks of indigestion.

"The best form in which to feed wheat is to roll or grind it into a coarse meal. It may then be fed alone, or mixed with corn meal or ground oats. When ground fine it is pasty and adheres to the teeth, gums and cheeks so that it is not so readily masticated or eaten. In the form of a coarse meal it is relished by all animals, it is in a condition to be attacked by the digestive processes whether thoroughly masticated or not, and in most cases it gives the best results. Dr. Gilbert appears to have obtained better results from whole than from ground wheat when fed to sheep. Sheep feeders may, therefore, experiment with whole wheat, but wheat meal will certainly be found to give better results with all other kinds of animals.

"The number of pounds of live weight that may be produced by feeding a bushel of wheat will evidently vary according to the age and condition of the animal fed. Prof. Robertson, at the Ottawa Experiment Station, fed frozen wheat to hogs and secured from 9.1 to 15.46 pounds, live weight, from a bushel, the greater increase being from young growing animals, and the smaller from those which were fattening.

"From the Canadian experiments it would appear that the feeding value of an equal weight of wheat is slightly in excess of that of corn; the South Dakota experiments gave better results from corn. In general, the difference would probably not be very great, but it would undoubtedly be better to mix corn and wheat, or corn, wheat and bran, or corn, wheat and middlings. The following examples show the composition of such mixtures:

	Protein.	Carbo-hydrates.	Fat.	Nutritive ratio
Mixture No. 1:	Pounds	Pounds.	Pounds.	
50 pounds corn	3.5	31.3	2.1	
50 pounds wheat	4.6	27.9	0.9	
100 pounds mixture	8.1	59.2	3.0	1:8.1
Mixture No. 2:				
40 pounds wheat	3.7	22.3	0.7	
40 pounds corn	2.8	25.1	1.7	
20 pounds bran	2.5	8.8	0.6	
100 pounds mixture	9.0	56.2	3.0	1:7.0
Mixture No. 3:				
40 pounds wheat	3.7	22.3	0.7	
20 pounds corn	1.4	12.6	0.8	
20 pounds oats	1.8	8.9	0.8	
20 pounds middlings	2.4	8.4	0.6	
100 pounds mixture	9.3	52.2	2.9	1:6.3
Mixture No. 4:				
60 pounds wheat	5.5	33.4	1.1	
20 pounds oats	1.8	8.9	0.8	
20 pounds middlings	2.4	8.4	0.6	
100 pounds mixture	9.7	50.7	2.5	1:5.8

"Many other combinations might be made, but these are sufficient for purposes of illustration. Mixtures 1 and 2 are more suitable for fattening animals, while 3 and 4 are excellent either for growing animals or for those being fattened."

PROFITABLE FEEDING PERIOD.

The most successful pork growers feed the pig to his fullest capacity from the time he is dropped until he is marketed, with food rich in muscle and bone making nutrients. They contend that anything short of this will lessen the profits. There should be no standstill or storage period. The points in favor of full feeding and early maturity as discussed by Stewart are these:

1. In the young, immature animal, the appetite, the

digestive and assimilative functions are most active and they grow less and less so as maturity is reached, the animal eating and digesting only an amount necessary to supply the waste of the body and keep up heat and respiration.

2. The percentage of waste while in the young and active stage of growth is much less than it is at and after maturity.

This point is quite important. The food of support—that necessary to supply the constant waste of the system and keep the animal without gain or loss—increases to a large item at maturity. From the begining to the end there is a constant increase in the amount of food required to produce a pound of live weight.

3. The risk is lessened.

4. Quicker returns from the investment, hence greater profit.

5. Better quality of meat.

The demand at present is not for the overgrown, excessively fat pig,but for that which gives the largest per cent of muscle or lean meat of the very best quality. The time to secure this is when the animal under the best system of feeding has just reached maturity; when the muscles are fully developed and when continued feeding would only add fat.

METHODS OF PREPARING FOOD.

I shall not undertake a discussion of all the questions that may come up under this heading, for many of them are not definitely settled and all may be open to farther experimentation. I believe the experiments as a whole favor grinding and wetting the grain, but not cooking it. On two of these points some very strong evidence is given below:

WET VS. DRY FEED.

On this subject Prof. Henry in the fifth annual report of Wisconsin Station, says:

"It will be seen from the above that the hogs fed upon dry feed in no case did as well as when their feed was wet. The difference is too great to be called accidental, and it is quite apparent that in these cases we lost feed by not wetting it. It will be noticed that the hogs getting the wet feed ate considerably more than when given dry feed and to this fact in a measure we may ascribe the greater gain from the wet feed.

"The writer's experience in hog feeding points plainly to one rule which he believes can be taken as a standard for the present at least; that is, other things being equal, *feed the hogs in such a way as to get them to eat the largest amount in a given time without waste.* By following this general rule I think the best results will be attained. In conducting experiments with cooked and uncooked feed it was found that a hog would eat more uncooked feed than cooked and in these experiments we note that he ate more wet feed than dry feed. Since we desire him to eat the maximum quantity per day it would seem that in some cases at least wet feed is superior to cooked feed on the one hand, and dry feed on the other." The ration was made up of equal parts of cornmeal and shorts.

The following on the same subject is taken from Bulletin No. 28, of the Oregon Station:

"From the outset the pigs fed on wet feed seemed to relish their food better than those fed on dry. Seemingly it did not require so much effort on their part to eat their ration as it did the dry fed lot. The pigs fed on wet food would eat their food in much less time than the others. By averaging the several periods we find that it required 4.64 pounds of food to make a pound of gain in live weight in the dry fed lot, and 4.46 pounds in the pen fed on wet food."

In the above experiment shorts were fed during the first period and equal parts of bran, shorts, chopped wheat and chopped oats for the rest of the time.

COOKED VS. UNCOOKED FOOD.

The following summary of the results of all the experiments on this subject conducted at the different Agricultural Colleges, collated by Prof. Henry, seems to decide the question conclusively in favor of the uncooked food.

SUMMARY.

AGRICULTURAL EXPERIMENT STATION, WISCONSIN.

Cooked barley meal (4 trials) was to uncooked as	93.7 to 100
Cooked corn meal (2 trials) was to uncooked as	81.0 to 100
Cooked corn meal and shorts (2 trials) was to uncooked as	96.1 to 100
Cooked whole corn and shorts (2 trials) was to uncooked as	85.8 to 100

ONTARIO AGRICULTURAL COLLEGE.

Cooked peas (2 trials) were to uncooked as	84.9 to 100

MICHIGAN AGRICULTURAL COLLEGE.

Scalded corn and oatmeal was to wet meal	101.7 to 100

KANSAS AGRICULTURAL COLLEGE.

Cooked shelled corn was to uncooked corn as	84.0 to 100

IOWA AGRICULTURAL COLLEGE.

Cooked shelled corn (2 trials) was to uncooked as	82.3 to 100
Cooked corn meal (2 trials) was to uncooked as	79.3 to 100

MAINE AGRICULTURAL COLLEGE.

Cooked corn meal (9 trials) was to uncooked as	82.9 to 100

"It will be noted that in every instance but one, that at the Michigan Agricultural College, there is a loss resulting from cooking; in the exception the gain is very slight, being less than two per cent. Even in this case the meal was not really cooked, but scalded by boiling water being poured on to the meal in a pail and covered up, while the other meal was fed wet with water."

CONCLUSIONS.

"Surely we have data enough before us to warrant the statement that there is a positive loss in cooking food for fattening hogs.

"These results are a surprise to the writer as they may be to the reader, for while one may suppose that it might be shown that there is no gain by cooking, it is remarkable that there should be a positive loss thereby. While unprepared to explain this loss by cooking to the satisfaction of all our readers, we may note the following: Hogs fed cooked food do not consume quite so much as a rule in a given time; as gain in weight comes from the excess of food digested above that required for maintenance, then the extra amount consumed might all go to give increased weight.

"We have the facts, and have them in such shape that they can be used by our farmers; it will require careful research to give the reasons, but in practice we are certainly warranted in not cooking food for fattening swine."

.679
M92b

UNIV. OF MICH.

BULLETIN NO. 4.

MONTANA
AGRICULTURAL
EXPERIMENT STATION

GLANDERS.

With Seven Illustrations.

BOZEMAN, MONTANA, JUNE, 1894.

Bozeman Chronicle,
Book and Job Printers.
1894.

Yerkes & Fell,
Book and Job Printers,
Bozeman, Montana.

MONTANA AGRICULTURAL

EXPERIMENT STATION.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman.
Peter Koch, Secretary and Treasurer	Bozeman.
George Kinkel, Jr., Vice President	Manhattan.
Walter Cooper	Bozeman.
E. H. Talcott	Livingston.

EXPERIMENT STATION STAFF.

S. M. Emery	Director and Horticulturist.
Luther Foster, M. S. A.	Agriculturist and Botanist.
F. W. Traphagen, Ph. D., F. C. S.	Chemist.
W. L. Williams, V. S.	Veterinarian.
A. M. Ryon, C. E.	Irrigation Engineer

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

Montana Experiment Station,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

BOZEMAN, MONTANA, June, 1894.

S. M. EMERY,

DIRECTOR AGRICULTURAL EXPERIMENT STATION,
BOZEMAN:

SIR: The following bulletin upon glanders is designed to bring to the notice of Montana horse-owners the various forms which this disease assumes under varying conditions, and especially to the character it presents under the influence of the climatic and other conditions resulting from the high altitude and dry atmosphere of the Rocky Mountain region.

One of the chief causes for the prevalence of glanders in this and other Rocky Mountain states is the very different form which the disease assumes in comparison with other states and it is chiefly through a better understanding of these variations, on the part of the horse-owners, that we can hope to successfully combat it.

The constant aim has been, while maintaining scientific accuracy, either to use common language or in case of the use of technical terms to follow them immediately by common explanatory words.

Respectfully submitted,
W. L. WILLIAMS, V. S.

Montana Experiment Station.

Bulletin No. 4. June, 1894.

GLANDERS.

BY W. L. WILLIAMS, V. S.

Glanders, and its external form designated as farcy, has been known from early antiquity, having been described by Aristotle in the fourth century before Christ.

In the fourth century A. D., Apsyrtus, a veterinary officer in the army of Constantine the Great, described both glanders and farcy, and at about the same time Vegetius described both as contagious diseases, advised the separation of diseased from healthy animals and the careful disposition of carcasses of animals which had died from or been killed for glanders. From the 12th to the 19th century glanders was frequently described by leading veterinarians, their writings increasing in interest and volume as the disease became more and more common and widely diffused.

The ideas of the various writers were naturally somewhat discordant as the nature of the disease was then little known. It was quite universally held by early writers that glanders and farcy were identical, and received their names from a difference in location of the effects of the disease. A few held that glanders and farcy were two distinct diseases. The acute or severe form of glanders was uniformly recognized as contagious and generally also the chronic or mild form was regarded as transmissible, but there were some veterinarians who denied the contagiousness of the latter.

The most important controversy among veterinarians of the early and middle ages and up to almost the present time was the source or origin of the disease. While practically all were agreed that most cases originated entirely by contagion, most of them strenuously maintained that it frequently arose spontaneously owing to other diseases or to debilitating influences, such as severe strangles or distemper, exposure to cold or wet, severe work, extreme blood-letting, partial starvation. the use of damaged hay or grain, unhealthy, overcrowded stables, overfeeding, etc.

Chief among those contending that the disease arose only through contagion was Gerlach, of Germany, who about 1868 stoutly asserted that it could not arise spontaneously. At the other extreme stood Delafond, one of the ablest veterinarians of France, who taught that only in the acute form could contagion occur, and that consequently chronic glanders should not come under police control.

The advent of the microscope as an aid in the study of medicine exerted the same influence in relation to glanders as with other diseases, and early in the latter half of this century the renowned Virchow described the microscopical appearance of its diseased parts, especially describing the changes taking place in the glanders tubercles or nodules existing in various tissues of the body, chiefly in the lungs.

Finally, about 1881, several investigators, among them Bouchard, Capitan and Charin, found in the discharges from the nose and in the lungs, spleen and other organs, a bacillus which they cultivated artificially in meat broth and from the fifth generation of these cultivations induced glanders in cats, guinea-pigs and asses.

Closely following the work of the above investigators Lœffler and Shutz, of the imperial health office at Berlin, succeeded in cultivating upon sterilized blood serum of the horse and sheep the pure glanders germ (*bacillus malleus*) from the tubercles found in the lungs and spleen of glandered horses, and with these pure cultures transmitted the disease to rabbits, guinea-pigs, horses and field mice.

This work of Lœffler and Shutz in 1881 definitely established the fact that glanders is a specific contagious disease, due solely to the glanders bacillus, and that the disease is incapable of spontaneous generation, but must at all times depend upon the presence of the bacilli which must in turn be derived from parent bacilli of the same kind.

The essential nature of the disease having become known, glanders has been the subject of much study and investigation by eminent veterinarians and bacteriologists. The most of these investigations have been in relation to the character of the bacilli and the glanders lymph or mallein first described by Kalning and Helman in 1891, a product of the glanders bacillus which when injected into the system of a horse affected with glanders causes a marked elevation of the body temperature or fever.

Probably no contagious disease of the horse is so widely spread, there being but one country—Australia—so far as we can learn in which the horses are reputed to be wholly free from glanders. Its prevalence in different countries varies very greatly, however, and there are also great variations in the prevalence of the disease in the same country at different epochs. It affects not only the horse but spreads by contact directly or indirectly to the ass, mule, and other solid hoofed animals and to man.

It is readily transmissible by inoculation also to guinea-pigs, rabbits, some species of rats, field mice and other small animals. Through the eating of the meat of glandered animals the disease has been observed in dogs, cats, lions, panthers, tigers, etc. It has been transmitted to the sheep and goat. Pigs are not readily, if at all, affected, while cattle apparently resist the disease entirely.

The disease has been recognized in man since 1821 and re-inoculated from man to the horse or ass, produces the malady in its usual form. Of solid hoofed animals, although the horse is most frequently affected, the mule and ass contract the disease more readily and it is more rapidly fatal among them.

CAUSES.

The cause of glanders and farcy, as has already been stated, is a living organism belonging to the group known generally as bacteria under the specific name of *bacillus malleus* or glanders bacillus. Glanders bacilli are straight or very slightly bent cylindrical rods in length ⅛—⅔ the diameter of a red blood cell and one-eighth to one-fifth as thick as long; 1-9000th to 1-6000th inch long, 1-60,000th to 1-40,000th in. thick. These germs are readily cultivated in blood serum or in bouillon from the flesh of the horse, in gelatin or on potato. The glanders germ has not been found growing outside the animal body except in artificial cultures, and it is consequently held that the disease can be obtained by animal or man only from an affected animal either directly or indirectly. The germs outside the body retain their life and vitality under ordinary conditions in a moderately dry state for four or five months, although when exposed freely to *very* dry air with sunlight they probably perish in a few days, and when in water or decomposing fluids they perish in two or three weeks. On the other hand when large quantities of glanders matter is thickly smeared or spread over stalls or mangers in stables where it is protected from rain and in a measure from light and the deeper parts well excluded from the air the germs seem to retain their vitality for a year or more.

PATHOLOGY.

The glanders germ being much smaller than blood cells permits their being carried by means of the blood and lymph, or absorbent vessels to all living parts of the body. The lymphatic or absorbent vessels are apparently more active in distributing the germs over the body than are the blood-vessels. The bacilli or germs multiply very rapidly, and show a marked tendency to the formation of clusters or groups in various tissues. When inoculated beneath the skin or into a wound the germs usually multiply quite rapidly for a time in the immediate part, causing great pain, swelling and in white or light colored skins, redness.

The local irritation caused by the presence of the germs and the poison given off by them may cause the formation of a pustule or boil (farcy bud) which may break and discharge pus or matter and may heal rapidly or slowly, or in some cases tend to constantly spread, forming an unhealthy, erodent or eating ulcer.

Later the local symptoms may partly or wholly disappear and a general dissemination or scattering of the disease over the entire body occur. Externally in the skin or parts immediately beneath it, successive crops of farcy buds may appear along the course of the lymphatic or absorbent vessels spreading from the point of inoculation toward the heart, these farcy buds occurring in the lymphatic glands (commonly known as "kernels") while the lymphatic vessels extending between the glands become swollen, making a line or ridge connecting the glands with each other, and giving the appearance of a rosemary.

Prominent among the disease processes taking place are those to be observed in the lining membrane of the nostrils, especially that portion covering the partition between the two nostrils—the septum nasi. The glanders germs multiplying here cause the formation of a small papule or pimple with a hardened base which matures somewhat rapidly, pus or matter forms, the pustule breaks and discharges its contents, leaving a ragged looking ulcer with abruptly raised edges, the center of the ulcer being depressed below the surrounding surface (see A in Figs. I, II, 1 and III). These papules are small in size, about that of a grain of mustard to that of a small pea, and the consequent ulcer may be of but little greater extent and in mild cases may not be deeper than the mucous or lining membrane, and once the pustule has ruptured the ulcer may heal promptly without leaving a scar as would be the case in Fig. III. Usually, however, the ulcer spreads, attaining a diameter of one-eighth to three-sixteenth inches or more; and extending down into the parts beneath the mucuous membrane as seen at A in Figs. I and II,1, in which case if the disease is sufficiently mild in character the ulcers heal somewhat slowly, leaving a white, wrinkled, stellate (star-shaped) scar which remains for years.

In many other cases the ulcers in the nostrils are very numerous and the area of each gradually extends until several or many of these become confluent or united into one extensive ulcerating patch which may cover the entire nasal partition on one or both sides, as in Figs. VI A to A and the entire surface of Fig. V, and these ulcerating, eroding patches may extend deeper until the cartilaginous (gristly) frame work of the nasal partition is reached and even perforated from side to side, as seen at B Fig. II 2.

Finally these extensive ulcerating patches may entirely heal, owing to improved condition of the animal, leaving very pronounced, permanent scars, as at A Fig. VII and B Fig. I. The mucous membrane lining the outer wall of the nostrils and covering the thin turbinated bones attached to the outer nostril wall, one of which is represented at 1 Fig. II, are affected the same as that covering the nasal partition but usually to a less degree, and the same is true of the lining membrane of the large sinuses or cavities of the face.

These disease processes result in a discharge from the nostrils corresponding in kind and amount to the ulceration. During the earlier stages, when the pimples are forming, the irritation causes a serous or watery discharge corresponding somewhat in quantity to the number of chancres or pimples. This is followed when the nodules rupture and ulceration begins, by a thick, transparent, sticky discharge which, in case of very extensive ulceration as in Figs. V and VII, is likely to be mixed with blood, due to the ulcerating process destroying the walls of blood-vessels. Should the ulceration extend deeper and involve the cartilage, as seen at A in Fig. V, or the bone, the discharge becomes very abundant, flaky and clotty and extremely fetid (stinking). As the ulcers heal, in cases where there is a tendency to recovery, the discharge correspondingly diminishes in amount and loses, if it has ever attained, its stinking or bloody character, becoming white, transparent and sticky and finally disappears wholly when the ulcers have all healed.

The changes which we have just described as occurring in the nostrils are quite commonly met with also in the larynx or upper part of the windpipe, the irritation from these ulcers producing a frequent hacking cough, quite peculiar in character, differing from the cough caused by other affections.

The organs most universally affected in glanders are the lungs, the disease comporting itself in this respect much like tuberculosis (consumption). In many cases the lungs appear to be the part first infected, due to inhalation of the glanders germs, an accident which cannot well happen except when an affected and a healthy animal are in close contact and breathing forcibly, as when working together and drawing a heavy load; or when closely confined in a crowded, illy-ventilated stable. When not primarily affected in this manner, the glanders germs in most cases soon find their way to the lungs from the diseased parts by being carried through the blood stream.

Once in the lungs the glanders germs become lodged and multiply, forming small colonies or clusters around which a tough, clear capsule or sac is formed, enclosing them more or less perfectly, forming glanders tubercles or nodules usually about the size of a mustard seed. These tubercles may soften and break open, freeing the glanders bacilli, or their walls may become thickened and hardened by the deposit of lime, the germs being securely enclosed and tending to finally perish in their prison-like surroundings.

When these tubercles become very numerous they may interfere with the patient's breathing by occupying too great a part of the lungs, thus diminishing their capacity and causing thereby a jerky breathing somewhat like heaves. In case of great numbers of tubercles, too, their presence is liable at any time, especially with slight exposure to cold or wet, to cause an inflammation of the lungs, or glanders pneumonia. The infection of the lungs generally corresponds in some degree with the general infection of the body, but is usually more pronounced in very old cases, giving the lungs upon post mortem examination a lumpy feel. In very dry, equable climates, especially at high altitudes, the number of tubercles in the lungs do not appear to be nearly so great as at lower levels, and the bacilli probably more frequently perish and the tubercles thereby disappear.

Glanders tubercles or nodules occur frequently in other internal organs, the liver, spleen, and other parts. At other times these deposits occur about or in joints or in the coverings of the brain and spinal cord or marrow of the back bone.

SYMPTOMS.

The symptoms of glanders must necessarily vaty greatly according to the parts chiefly affected and in what degree, whether the entire system suffers from the general infection, or if the disease be largely localized in one or more organs. Constitutional symptoms, such as fever, shivering, loss ot appetite, debility, and rapid loss of flesh are only induced in virulent cases or what is known as acute glanders, and these symptoms are due, not so much to the presence and action of the germs themselves as to the poisons given off by them. Consequently we observe in the first stages of acute glanders, before any distinctive signs present themselves, the general symptoms of an infectious fever, the animal showing dullness, shivering, staring coat, high fever, and other symptoms of general illness.

Should the attack continue severe, local symptoms characteristic of glanders generally become evident in a very few days, most uniformly and prominently in the nostrils. At first there appears upon the membrane lining the nostrils whitish papules or pimples of the size of a mustard seed or larger, having red bases. Pus or matter soon forms within them, the pimples rupture, leaving an angry-looking, ragged-edged ulcer, as seen about the margin of Fig. VI, which has a tendency to spread and enlarge, soon coalescing or uniting with other neighboring ulcers forming large ulcerating patches which may include the greater part or entire area of one or both sides of the partition between the nostrils, as seen in Figs. II, V and VI, and affecting as well, but usually in a lesser degree, the other portions of the nostril cavity, that is, the mucous membrane of the outer wall and the surface of the turbinated bones (small; elongated, thin, fragile bones in the nasal cavity attached to the outer wall of nostril) as at A Fig. II, 1.

This ulcerative process may extend through the mucous membrane and the tissues immediately beneath it and attack the cartilage forming the gristly framework in the nose partition, as at A Fig. V, or may even penetrate entirely through it, as seen in Fig. II, 2 B.

Between these severe cases and those in which there are no ulcerations in the nostrils whatever—a class of cases by no means rare—there is every possible gradation of symptoms, leading various writers to attempt to classify them as acute and chronic nasal glanders and some authors, finding it difficult to draw the line between these two, have added a third class described as sub-acute, but have failed to make the classification any more accurate or valuable.

These classifications of glanders into acute, sub-acute and chronic is purely one for descriptive purposes without any natural boundaries or differences, the chronic case frequently becoming acute, when the animal is exposed or attacked by other disease, and the acute in its turn changing sometimes to mild or chronic glanders, under the influence ot better care and surroundings, the two diseases united by imperceptible gradations making an exact classification impossible.

Even in severe cases, improvement is possible so that where the ulceration and death of tissue has extended so deeply as to perforate the nose partition by large openings, under beneficial conditions, betterment may occur to such a degree that the cartilage which has been laid bare is covered over with granulations and undergoing a marked process of healing, as in Fig. II, In somewhat milder cases of less duration, the ulcerated patches may not extend very widely but remain of comparatively small size 1/8 to 1/4 inch in diameter, as in Fig. I A, and not extending to the cartilage, while over the spaces intervening between these patches, isolated, small ulcers may be found as in Fig. I, at the lower portion. These smaller ulcerated patches show a much greater tendency to heal than do those in the more acute type accompanied by larger ulcerating patches extending deeper into the tissues. In healing, these patches, leave depressed, wrinkled scars like those shown in Fig. I B and Fig. VII A. In yet milder cases, the ulcerations are very small in extent and few in numbers, as in Fig. III, most all of these ulcers remaining entirely isolated and are very small and shallow. These solitary ulcers heal, leaving in some of the larger and deeper ones a small white scar, which has a tendency to wholly disappear in time, while in the smaller, and especially in the very shallow ulcers like those seen at A Fig. III, heal quickly, leaving no trace of their previous existence.

The majority of these ulcerations occur high up in the nostrils, where they are difficult or impossible of detection in the living animal, and they occur high up, beyond view, in proportion generally as the case is mild, while in the severe cases, where the nose partition is attacked and destroyed, this destruction occurs so far as we have seen, at the lower part of the nostril in plain sight. Consequently although there may be a considerable number of ulcers within the nostril, few or none may be in sight in mild cases and only discoverable by post mortem examination. The glanders papules or chancres. with their resulting ulcers, appear in successive crops, all stages being found at times in the same animal, new ulcers constantly forming, while older ones are healing, month after month, and year after year, in the milder cases where complete healing does not occur. This is well illustrated in Figs. I and VII in which at A in I and B in VII fresh ulcers are seen while at B in I and A in VII scars showing the seat of healed ulcers are apparent.

The presence of these ulcers in the nostrils is responsible for two of the most constant symptoms of nasal glanders:

nasal discharge and the swelling of the glands beneath the jaws, from which latter the disease derives its name, glanders, both of these symptoms being parallel generally to the amount of active ulceration occurring. If ulcers exist in both nostrils, the discharge issues from both, while when one side only is affected, the discharge comes from the affected side only while the swellings of the glands correspond generally in like manner.

In the early stages before ulceration has taken place, the discharge resulting merely from the irritated, congested mucous membrane, is thin and watery in character, but when the ulceration occurs the discharge becomes thicker, viscid, sticky, partly transparent, not unlike the white of an egg, and adheres, owing to its sticky character, to the hairs and skin about the edges of the nostrils where it forms hard, dry, tough, dirty, brownish crusts, which in drying, contract, tending to draw the edges of the nostrils inward, and decreasing either really or apparently, the size of the nostril opening. The discharge of glanders at this stage is of heavy specific gravity, somewhat heavier than water.

In severe cases, such as illustrated in Fig. V, considerable sized particles of the tissues die, and are cast off in the discharge giving it a flaky, dirty opaque appearance. In many of the severe cases the discharge is mixed with blood while in all cases of moderate severity, bleeding at the nose may occur owing to ulcers destroying the walls of the blood vessels, and thus allowing the free escape of blood.

There is generally no smell present in glanders, but when the ulcerations extend so deeply as to involve the cartilage of the nose partition, as in Figs. II, V and VI, the discharge then becomes very offensive and stinking. The discharge usually continues closely parallel to the active ulceration; as the ulcers increase in numbers, size and depth, the discharge increases while as the ulcers heal, the discharge diminishes, and when all have healed it ceases; to return again when, owing to exposure or other causes, the ulcers reappear.

The swelling of the glands beneath the jaws (sub-maxillary lymphatic glands) corresponds usually to the degree and character of the ulceration in the nostrils. These glands, normally barely capable of being felt by the fingers, lying loosely beneath the skin, of oblong shape about ¾ inches long by ¼ inches in diameter, soft and irregular in outline, soon change in size, consistency and sensibility upon the advent of nasal glanders. They increase in size from that of a peanut in the mild cases, to that of a large hen's egg in the severe ones, and become painful to the touch, usually in proportion to the degree of enlargement. The gland is very hard to the touch and presents a nodular or lumpy outline in almost all cases, but in rare instances suppuration or the formation of pus may occur in the gland, in which case the outline tends to become smooth and regular. Swelling of the glands is rarely absent in nasal glanders, but might occur after the formation of abcesses (collections of pus) in them and their consequent destruction, whether the abcess be due to glanders, strangles (distemper), or other diseases.

In rare cases, too, unprincipled jockeys and traders or ignorant quacks, remove the enlarged glands surgically, in order to deceive incautious persons or in the vain hope of thus curing the disease.

In almost all cases, however, if ulcers exist in but one nostril, the gland on the same side is affected, while that on the other side remains normal, and if both nostrils are affected both glands are diseased in like degree. Either one or both nostrils may be mildly or severely ulcerated. Figs. I and IV represent the two sides of one septum, one side diseased, the other healthy, and the septum represented in Fig. VI is perfectly healthy on the opposite side, while in Figs. II, V and VII both sides are almost equally affected. As the disease increases in severity, the gland or glands increase in size and tenderness, becoming smaller and less painful to the touch as the disease shows signs of recovery. At times the gland may be swollen out of proportion to the ulceration in the nostril or even may remain swollen when ulceration in the nostril is absent, owing to the presence of glanders nodules in considerable numbers in the substance of the gland. The swollen gland appears usually to be more firmly attached to the jaw bone and other surrounding parts than when enlarged from other diseases.

The breathing is rarely interfered with seriously in nasal glanders, but the nostrils may in severe cases become more or less badly blocked up by swelling of the diseased parts or by the collection of a great amount of the discharge within them or about their openings.

With, or, without nasal glanders there may be symptoms referable to diseased conditions of the lungs or air passages.

The larynx is frequently affected as previously stated, which induces a short, hacking cough, not unlike the cough of tuberculosis (consumption) in man.

When the lungs become extensively affected, many nodules being deposited in them, the breathing becomes disturbed, and as a result becomes hurried, the effort at expiration being short and jerky somewhat like heaves, but lacking the double expiratory effort noted at the flank in the latter disease.

In other cases where lung tubercles are present in abundance, inflammation of the lungs (glanders, lung-fever, or pneumonia) may occur, owing to exposure or other depressing causes, the lungs becoming hepatized (solidified or liver-like) in various parts, inducing all the symptoms of ordinary pneumonia along with any existing signs of glanders in other parts.

The symtoms which, next to nasal glanders, are most common and characteristic are those occurring in the external parts of the body and giving rise to that type of the disease usually known as "farcy" or "button farcy."

Farcy consists essentially of glanderous inflammation of the lymphatic (absorbent) glands* of the skin and parts immediately beneath them.

---

*The lymphatic or absorbent system consists of a series of small vessels much like veins, distributed thickly throughout the body, flowing toward the heart and ending near the heart in one of the larger veins. They take up from the tissues, fluid particles, containing some small cells or corpuscles forming a liquid known as lymph or "white blood" which is finally emptied into the blood vessels just before reaching the heart. This lymph in passing from the surface of the body to the heart passes through one or more lymphatic glands (kernels) in which the lymphatic vessels are broken up into very fine branches and folded upon themselves in an intricate manner.

Farcy may be either primary or secondary, that is, it may exist before internal glanders has become established, due to inoculation at or near the affected part, or it may develop late in the disease as a result of general infection of the system. Farcy is due to the growth and irritation of glanders bacilli and to their poisons in the lymph glands and vessels, the glands becoming swollen and painful to the touch, increasing in size during few to many days, according largely to the virulence of the disease, when finally suppuration (or the formation of pus) occurs, the enlarged gland softening and rupturing, discharging pus (or matter) which varies much in consistency according to the virulence of the disease, in some of the milder cases being thick, yellowish white, drying into dirty brownish crusts about the edges of the open abscess, while in more severe cases it may be thin, flaky, foul smelling, bloody and irritating, excoriating the skin over which it runs, removing the hair, and leaving the skin raw. The abscesses (farcy buds) vary in size, partly according to the size of the gland undergoing suppuration so that near the feet farcy buds on the legs are usually quite small, at times no larger than a small pea, while as the disease ascends toward the body the farcy buds or boils become larger and larger, finally reaching at times the size of hen's eggs along the inside of the thigh or in the groin. The severity of the attack also modifies the size of farcy buds, they being usually larger as the disease is more severe. As a rule the abscesses form a series, appearing successfully from the most external parts along the course of the lymphatics toward the heart. For example, if farcy begins at or near a hind foot, the glands nearest in the course of the lymphatics first suppurate and break, followed closely by those next above, these to be followed again by those still higher until the groin is reached and the lymphatics disappear within the belly.

The lymphatic veins or vessels stretching between the affected glands become swollen and cord-like thus connecting the entire series of glands into a rosemary-like chain.

In severe cases the ulcers, resulting from the rupture of the farcy buds, are very unhealthy and may spread rapidly, showing no tendency whatever to heal, or in less severe cases they may heal tardily, leaving a hairless scar, while in very mild cases they heal promptly, leaving but a slight scar.

In most cases of farcy the parts in the neighborhood of the suppurating and ulcerating lymph glands become inflamed and swollen, the swelling frequently persisting for a considerable time after the healing of the ulcers.

Farcy rarely exists independent of internal glanders, but when primary, that is, when it is the result of inoculation in the affected part, it may remain wholly local for several months and in rare cases recover without general glanders developing.

Since glanders is, with rare exceptions, a constitutional malady and almost all organs and tissues subject to infection through the blood and lymph, the disease is likely to develop at any time, peculiar and uncommon symptoms referable to disease changes taking place in organs or parts not generally much affected. Occasionally in well marked cases of glanders, at other times in cases where the usual symptoms are wholly wanting, severe inflammation of a joint may develop very suddenly, rendering the animal able to put little if any weight upon the affected limb. This glanderous inflammation of joints appears without known cause, and usually persists for a considerable length of time, leaving in many cases, changes in the joint which are likely to cause the revival of symptoms at any time, for the most trivial reasons.

In other cases the joints in the neck or the coverings of the spinal cord (or marrow) in the neck may suffer from glanderous inflammation resulting in an extremely painful, stiff neck in which the animal carries the head and neck rigidly in as nearly as possible a straight line, unable to lower or raise the head or bend the neck either to the right or left. These symptoms may be accompanied by those common to either glanders or farcy, or may be the first symptoms observable. Bleeding at the nose without apparent cause is not infrequent in cases of glanders even though no ulcerations in the nostrils are apparent.

In a large number of cases of glanders the symptoms are very slight, and not infrequently no symptons are discernible whatever upon ordinary examination even though the animal may have been affected for months or even years.

In some cases, when distinct local symptoms are wanting, there is a general want of thrift, with rough staring coat, and perhaps an occasional hacking cough.

In other cases, there may be evidences of previous ulcerations having taken place in the nostrils, in the form of small whitish star-shaped, wrinkled depressed scars, while in some animals the disease may be limited solely, so far as can be found upon post-mortem examination, to the existence of glanders tubercles or nodules in the lungs or other internal organs to such an extent as not to interfere with their normal functions, the animal remaining fat and presenting in general all signs of robust health, and perfectly capable of performing ordinary work for months or years, at all times retaining good general health. These forms of the disease, unrecognizable by means of ordinary examination, have been variously described as latent, internal or masked glanders.

These wide variations in the symptoms of glanders are in a great part explainable, the disease being delicately sensitive to any and all surroundings and conditions which in any way affect the general health of the patient.

Influences which Modify the Symptoms and Character of Glanders:

CLIMATE.

Of all conditions affecting glanders, climate exerts the most notable influence, rendering the horses of some countries almost wholly exempt, while those of other countries suffer extensively and severely. The disease has been for many years extensive and severe throughout central and northern Europe, and Great Britain. Although having a large number of horses the Australian continent is said to be free from the disease, no outbreak having thus far been recorded, although it is scarcely possible that no animals affected with glanders have been imported to that country.

In British India.(1) the disease has at times been extensively imported but was readily eradicated and native animals appear immune.

In southern Russia and in Roumania and Italy, glanders is very prevalent. Prof. V. Babes of Bucharest, Roumania, from careful investigation estimates that 30 per cent to 50 per cent of the horses in that and other Roumanian cities are affected with glanders, but in a very mild form, generally showing no external signs, and frequently recovering spontaneously. In south Russia and in Italy the disease appears little less common than in Roumania and assumes a like mild type with frequent recovery either spontaneously or with treatment. It also prevails in Africa and in north China.

The immunity of horses against glanders in Australia and British India is, so far as can be seen, referable almost wholly to climatic influences, chiefly to the light rain fall, regular temperature, and dry atmosphere, and similar conditions serve to render the disease unusually mild, permitting many of the affected animals to recover in southern Russia, Roumania and Italy.

These influences are very marked also in America. In Mexico, glanders occurs rarely, is not inclined to spread and runs a very mild course.

In the United States we find marked variations in different localities.

In the Atlantic, Gulf and Mississippi Valley States the disease prevails to a considerable extent and in rather severe form.

Even in those states however, three fourths or more of the horses have the disease in the mild or chronic form, so that they will live for several months or even years, while some of the affected horses will remain fat and vigorous, and perform ordinary work without difficulty for several years, and occasionally they apparently recovery, although as a rule still capable of transmitting the disease. A smaller number of the diseased animals in these states are affected in the severe form, the affection running a rapid course, ending in death in from 15 to 60 days.

---

(1) Fleming's Veterinary Science and Police, Vol. I, P. 179.

As we approach the high plains sloping eastward from the Rocky Mountains the disease, although quite common, is very mild and the acute or severe type is seldom witnessed, most affected animals living for months and even years in good condition.

In the higher altitudes of the Rocky mountains and along their western slope the disease assumes a still more mild type, being very rarely seen in the severe form, but usually of a very mild character which under favorable surroundings does not materially affect the vigor of the animal even though at reasonable labor, so that the lives of most affected horses are not shortened greatly if at all by the disease but generally live for an indefinite number of years, while many diseased animals show no external symptoms whatever, and many horses at one time plainly affected with glanders make apparent recoveries and remain to all appearances sound for years.

When however, the weather is inclement, stormy and wet the disease tends to develop in the severe form as was seen in Montana during the fall, winter and spring of 1893-94, but upon the advent of summer with the usual dry weather the acute form disappeared and the disease is rarely reported, not because it is less rare but because it assumes largely a type which is unrecognizable.

When the Pacific coast is reached glanders re-appears in the humid localities near the sea level in its severe form, and runs the same course, with like symptoms as seen in the Atlantic states.

Since the disease is due to the transmission of glanders germs usually contained in the discharge from the nostrils or from farcy buds of affected animals to those which are healthy, and since as a rule the glanders germs are most abundant and active in severe cases, it naturally follows that the contagiousness of the disease is in proportion to the severity it assumes in the animal to which the healthy one is exposed, hence the disease is most contagious under those conditions which make it most severe in the affected animals and least contagious where it assumes a very mild type.

Thus we find the disease highly contagious under one set of conditions, and very feebly contagious under others.

STABLING.

The housing of animals was primarily intended to counteract injurious effects of climate but in many cases has become a matter of convenience, permitting the concentration of animals within a limited area.

So long as stables are designed properly and solely for the protection of horses against inclement weather, they exert no untoward influence upon glanders, but may on the other hand, tend to lessen the severity of the disease in inclement seasons.

Almost always, however, this highest aim of stabling is not attained nor even approached, and as a result, it is almost always found that horses which are closely stabled suffer often and severely from glanders.

The close confinement of a large number of horses in a badly ventilated stable acts injuriously in several ways when glanders (or other contagious diseases) exist in it.

In the first place, infection of healthy horses is more likely to occur when thus crowded together through close contact of healthy with diseased animals as well as indirectly through contaminated food, water, stable utensils, clothing of attendants, and other similar methods.

Another active factor is the depressing and injurious effect close housing has upon the general health of horses.

The close air of crowded, ill-ventilated stables, while destroying the general vigor of the animal, directly favors the growth and vitality of the glanders germs, and they probably live and retain their vigor much longer in an atmosphere impure from close crowding of animals.

It has been shown experimentally that in tuberculosis (consumption) the disease is not readily carried from affected to healthy animals by means of ordinary dry air, while when they are closely confined in an atmosphere saturated with moisture the disease is readily communicated and bearing in mind the close relationship of glanders and tuberculosis, it would be expected that the former would spread readily from horse to horse, in a close stable, rendered damp either by location or through want of ventilation, a suggestion fully borne out by observation.

It must be remembered, too, that stabled horses are more subject to colds, and these render infection by glanders more probable.

This largely accounts for the increased prevalence of glanders and in a severe form, in large cities where horses are closely crowded in hot, damp, ill-ventilated basement stables.

Even in country districts, horses kept stabled are more subject to glanders and usually suffer in a more severe form than those not confined.

Glanders of the most severe type possible develops at times on ship board, where a large number of horses, among which one or more animals are glandered, are crowded into the hold, especially when, upon the occurrence of rough weather, it becomes necessary to close, water tight, all openings serving for ventilation.

On the other hand, animals running at large, except the weather be very inclement, generally show the disease in a mild form, and but feebly contagious.

LABOR.

The character of work required exerts a very marked influence upon the disease, severe labor almost always increasing the severity of the affection, while moderate labor is frequently borne for months and even for a series of years without ill effect.

In the more severe cases of glanders, labor greatly hastens death in proportion to the severity of the work required. In the more acute type of the disease, with excessive nasal discharge, high fever and the resulting extreme weakness, the affected animal is totally unable to perform labor, and in all cases, overwork constantly tends to aggravate the disease.

Even in mild cases a hard day's work, especially at a rapid pace, very frequently causes a renewal of the nasal discharge, which has been absent for weeks or months, or being present to a limited extent, is very greatly increased. Under very severe labor, too, cases of long standing which have not shown visible signs of disease, may suddenly develop well marked symptoms.

FOOD.

Food exerts essentially the same general influence in the course and character of glanders as it does in other diseases, through its good or evil effects upon the general system, except perhaps that overfeeding produces less evident harm in animals affected with glanders than among those suffering from most other diseases. A want of suitable amount or quality of food quickly increases the severity of this affection.

BREED.

It has been stated that in some countries certain breeds of horses suffered more severely as well as more frequently from glanders than did others, especially it has been charged that the coarse draft breeds suffered more severely than the lighter types.

In this country, however, such can not be said to be the case, but so far as can be seen all breeds suffer alike and the difference in prevalence in different types of horses in a community can be readily referred to other influences than that of breeding.

AGE.

The age of an animal affected with glanders modifies the symptoms and course of the disease very much, especially at its beginning.

The older the horse is when attacked the more virulent the disease, and in horses beginning to show infirmity from age, glanders usually assumes a very severe type ending in a short time in death, but in those animals which have become affected while young, and the disease has assumed a mild chronic form, this type persists even through a number of years, the constant increase in age of the animal apparently having no evil effect on the course of the disease.

Colts are rather seldom attacked and usually in a decidedly milder form than in mature horses.

The symptoms and character of the disease are consequently subject to a long list of influences, several or many of them possibly working at one and the same time, some combining to render the disease severe, others tending in precisely the opposite direction.

Thus, in Montana, especially in certain valleys during the past year there has been an unusually great rainfall, with inclement storms, and much cloudy weather. This wet weather succeeded a severe drouth with consequent short pasturage, and coming at a time when grain was yet in the field it was greatly damaged so that neither the grain, straw, nor grass were of as good quality as usual, these all combining caused the disease to show itself in a decidedly more severe form than it usually assumes in this state.

In army horses the disease generally assumes a severe form, especially when engaged in an active campaign, in which case along with hard work the animal suffers from lack of proper food, irregularity, exposure to inclement weather perhaps in a country to which the animals are not acclimated and in every way all causes which usually tend to increase the severity of the disease seem combined to make a virulent type certain, so that a comparatively large portion of glandered army horses show the disease in a rapidly fatal form.

So it is in a lesser degree with many freighting, stage and street car horses where we find overwork, great exposure, careless feeding and a general want of such attention as would insure vigorous health, all combining to render the disease more deadly.

We consequently find the disease more severe usually among government troop horses, and in the extensive stables of large corporations, than we do among private animals, except in those cases, unfortunately too common, where through poverty or carelessness of the owner, horses are harshly treated and badly neglected.

DIAGNOSIS.

Under all the varying conditions which serve to modify the character of the disease so profoundly, the diagnosis of glanders is frequently very difficult and not rarely impossible by physical signs. In Montana there are probably five glandered horses showing no external signs of glanders whatever, to one showing external signs even though of a mild character.

In many cases the symptoms are so typical that the disease is readily recognizable. The farcy buds when occurring in any great number are usually so typical in character as to leave no doubt as to their precise nature, no difference upon what part of the body surface they may develop.

In nasal glanders, the most characteristic and decisive symptom is the presence in sight of the typical glanders ulcers as seen in Fig. I or at A Fig. II 2, or the large ulcerated patches of Fig. VI, or the peculiar scars left behind, when the ulcers have healed, as in Fig. VII.

These ulcers are not always plainly in sight, but may be brought into view by holding the nostrils well open and inclining the nose toward the sun in such a manner as to throw the sun's rays up the nostril, or at or near midday the light can be thrown into the nostril by means of a small mirror.

A very satisfactory means of illuminating the nostril is to examine the animal by night, in a dark stable, throwing the light from a reflecting lamp up into the nostrils. If these characteristic ulcers or their scars can be thus seen, the character of the disease is evident, but in some cases even though ulcers be present they cannot be seen, being too high up for examination. If however the discharge from the nostril be great, if glanders be present there will almost surely be abundant ulcerations within plain sight.

The discharge from the nostril is usually, though not always, quite characteristic of the disease.

It is usually thick, quite viscid and sticky, of a transparent, whitish color, discharging regularly, not usually in large quantities at one time and none at another, varying in amount in proportion to the amount of ulceration present at a given time, increasing with increased ulceration, and decreasing with improvement.

Sharp exercise usually causes an increased discharge. The great viscidity of the discharge adhering closely to the margins of the nostrils, turning to hard, tough, dirty-brownish scales is rarely seen to the same degree in other diseases than glanders. There is rarely any smell to the nasal discharge except in cases where there are extensive and deep ulcerative patches, in which the cartilage becomes affected as seen in Figs. II 2, B V. A and VI.

The swelling of the submaxillary glands (the small glands or kernels beneath the jaws) are usually quite characteristic in cases of glanders with ulcerations in the nostrils and the consequent discharge.

The enlargement of these glands in glanders, generally differs from their enlargement in other diseases by their comparatively small size, ranging from that of a peanut to a hen's egg, quite lumpy to the touch and very tender, the animal showing signs of pain when they are pressed upon. They also seem firmly attached to the lower jaw and other surrounding parts, In rare cases, the enlarged glands have a dropsical, puffy appearance.

Other symptoms, occurring with one or more of the foregoing, aid materially in arriving at a safe conclusion, such as bleeding from the nostrils, the peculiar hacking cough, sudden, severe and unaccountable lameness. A history of exposure to glanders is always of importance in suspected cases.

It is popularly supposed that the discharge from the nostrils of glandered horses will in all cases sink when dropped in water, and constitutes a certain diagnostic sign, but these discharges can only sink in water when they are the heavier, and the parts which are affected and the severity of the attack will cause variations in the specific weight of the discharge so that it may either sink or swim, a fact which generally is true of other affections accompanied by a discharge from the nostrils.

As already stated, in many cases the nasal discharge is very scanty and not infrequently wholly absent, so that while its character, when present, may be a possible aid in diagnosis it is not sufficient in itself.

The popular belief that glanders is, under all conditions, highly contagious, frequently leads owners of glandered horses to believe the disease to be some other affection of a non-contagious character, because other horses associating with the affected animal remain for a long time apparently well, but to one who understands how feebly contagious glanders may be under certain conditions will readily see that the disease may exist in a band for a considerable length of time without the appearance of new cases, and the inability of the owner to see new cases does not signify their absence, as it so frequently assumes a wholly unrecognizable form,

DIFFERENTIAL DIAGNOSIS.

Glanders may be, and not infrequently is, confounded with other affections somewhat resembling it in some of its symptoms, especially those diseases in which nasal discharges constitute a prominent feature.

NASAL GLEET.

Before dealing separately with those affections which may be mistaken for glanders, or *vice versa*, it will be well to consider briefly the term "nasal gleet" now obsolete in veterinay science but still used to some extent by horse owners and generally remains in the pages of inferior popular writings on the diseases of animals.

Nasal gleet means literally and simply "nostril discharge," and so can be applied with equal correctness to all diseases in which a discharge from the nostrils constitutes a symptom, and is therefore as appropriate a name for glanders as for any other affection.

The history of the term is that of a cloak for ignorance, and has been applied indiscriminately to any and all diseases exhibiting a nasal discharge whose nature was not understood. With the advance of our knowledge of disease, one after another of these affections were taken from the "nasal gleet" category and placed by themselves as separate and distinct disorders until the term has been wholly robbed of its significance to the scientific veterinarian, and is now only used as it was originally, to signify a discharge from the nostrils, the cause or nature of which is unknown to the party using the term. It is still popularly applied to glanders, especially in its mild or chronic form, while should this mild form become severe as it is likely at any time to do, they then quite commonly apply its proper name of glanders, and claim that the "nasal gleet" has developed into glanders, whereas in fact, mild glanders has become acute through some cause affecting the general vigor of the animal. The term is consequently a misleading and frequently unfortunate one, especially when applied to glanders, as it carries with it no suggestion of contagiousness, thus leading to the unlimited exposure of healthy animals to the disease.

STRANGLES.

Among the diseases at times closely simulating glanders one of the most common is strangles or distemper, an affection which, although in some respects closely resembling glanders, yet taken as a whole they present widely different symptoms.

The incubative period or time between exposure to the disease and its appearance, is very brief, ten to twelve days in strangles, while in glanders the disease rarely develops so promptly. Distemper is highly contagious and transmissible for some distance through the atmosphere, while in glanders close contact is necessary.

Usually when distemper breaks out in a band of horses it is but a very short time until nearly all animals which have not been rendered immune or proof against the disease by previous attack are affected with it, while in glanders the disease is much less contagious and spreads slowly.

The swellings of the glands beneath the jaws usually differ widely in glanders and strangles. In the former the discharge from the nostrils usually preceeds the swelling of the glands, while in the latter, the glands usually swell before any discharge from the nostrils occurs.

In glanders the enlargement of the glands is usually in proportion to the discharge from the nostrils and on the same side, so that if there is discharge from one nostril only, only the one gland on the corresponding side is swollen.

The enlarged glands are in both cases painful, but that of glanders is small in size, varying from that of a peanut or smaller to a large hen's egg, and is uneven and knotty while the gland enlarged from strangles is generally much larger than in glanders and is round and smooth in outline and bears no intimate relation to any discharge from the nostril although frequently seen at the same time.

The enlarged glands rarely suppurate or form matter in glanders while they nearly always do so in distemper, forming large abscesses which break generally at the crisis or turning point of the disease and discharge a large amount of pus, the abscess usually healing promptly.

In sharp contrast with glanders the course of strangles is usually quite rapid, ending generally in recovery or death in ten to twenty days, rarely continuing for a longer period than thirty days.

The discharge from the nostrils is usually less sticky than in glanders and is more opaque and white in color, and as a general rule far more abundant in quantity, being equaled in amount only in very severe cases of glanders.

PINK EYE.

Pink Eye or contagious Cellulitis of horses may at times be mistaken for glanders, but can almost always be readily distinguished from it by the rapid onset and course of the disease, the discharge from the nostrils being from both alike, not so clear and sticky as in glanders, and the glands beneath the jaws but slightly swollen, the mucous membrane lining the eyelids bright red and tears sometimes mixed with pus flow down over the cheek while in glanders, the eyes are usually very slightly affected, small quantities of pus collecting at the inner corner of the eye. The swollen limbs of "pink eye" differ from the swellings of farcy in generally attacking all four limbs at once very suddenly, and presenting no farcy buds or boils.

Pink eye is very rapid in its course ending in death or recovery as a rule in five to ten days. It is very highly contagious and spreads rapidly when once introduced, disappearing with almost equal promptness.

ACUTE NASAL CATARRH.

Acute nasal catarrh, due to exposure or "taking cold" is usually traceable to its proper cause and the discharge differs from that of glanders in being quite uniformly from both nostrils alike, the discharge less glairy and sticky than in glanders, and is usually accompanied by a very frequent cough differing from that of glanders in being louder and not of a short hacking nature.

In acute catarrh there is usually severe sore throat (pharyngitis) causing the animal to allow water to return through the nostrils when attempting to drink, and difficulty in swallowing food causing much of it also, to be at times returned through the nostrils giving the nasal discharge the color of the food, and showing particles of food mixed with it. If green grass is offered as food the nasal discharge assumes a dirty green color due to admixture of the juices of the grass with the nasal discharge.

INFECTIOUS OR EPIZOOTIC CATARRHAL FEVER.

Infectious or Epizootic catarrhal fever (epizootic) offers essentially the same symptoms as acute nasal catarrh, only that it becomes general, affecting a large portion or all the animals over a large area.

It spreads very rapidly and runs a rapid course, terminating usually in recovery, rarely, in death, in five to fifteen days.

CHRONIC NASAL CATARRH.

Chronic nasal catarrh due to a chronic inflammation of the lining membrane of the nostrils may generally be distinguished from glanders by an inconstant discharge from one or both nostrils of a white or yellowish white matter in lumps, which do not adhere much to the nostrils. This discharge is in many cases seen only when the animal's head is lowered to eat or drink.

The swelling of the glands between the jaws and the ulcers in the nostrils are not present.

DISEASE OF THE FACIAL SINUSES.

In the face, situated below the eye, toward the nose are several large sinuses or cavities opening by a small orifice into the nostrils, which at times become diseased and being designed only to contain air, pus forming within them does not escape but remains in the cup-like cavities until they are well filled, when they overflow into the nostrils, yielding a clotty, various-colored and frequently stinking matter.

The presence of this putrid matter in the sinuses produces in the course of a few weeks, generally, a bulging outward of the bones of the face over the affected part which can be plainly seen upon careful examination.

DISEASED TEETH.

Ulceration of the fangs of molar (jaw) teeth, and more frequently tooth tumors leading to excessively large growths upon the tooth fangs, which finally push their way into the sinuses of the face or into the nostrils, frequently lead to an abundant nasal discharge almost always extremely fetid (stinking) which usually lasts for several years unless properly treated.

In these cases the glands beneath the jaws may become swollen on the affected side, but the stinking character of the discharge, the absence of ulcerations in the nostrils and usually a bulging of the bones of the face over the fang of the diseased tooth, in many cases much difficulty in breathing, due to excessive collections of matter or tooth substance closing up the nostril cavity, frequently coupled with a difficulty in chewing food, serves generally to distinguish it readily from glanders. Still the exceedingly abundant discharge of a very repulsive smell corresponds so well with the popular but erroneous idea of glanders that many good horses are destroyed summarily when affected with diseased teeth only, and readily curable.

TUMORS, ETC., IN NOSTRILS.

Tumors of various kinds, nasal polypi and other diseased growths in the nostrils, most of which produce some discharge are at times mistaken for glanders, but may be generally distinguished from that malady by the great difficulty in breathing produced by the tumors, without any great nasal discharge, and in a large proportion of cases the tumor or other obstructing disease can be seen upon examination.

In all these diseases accompanied by nasal discharge the characteristic glanders ulcerations are absent.

Pieces of tooth tumors become detached rarely and in passing slowly down the nostrils abrade and tear the mucous membrane, which upon healing leaves corresponding, rough, irregular scars.

Suspicious scars are at times produced also by rough usage in handling, the mucous membrane on the partition between the nostrils being torn, by a man catching the horse in the nose with the thumb and fingers lacerating the mucous membrane with the finger nails.

In such cases the scars resulting occupy only the lowest part of the nostril where, as a rule, glanders ulcers are not common, and both sides of nasal partition are usually affected alike, while other portions of nasal septum are free from ulcers or scars.

Scars caused by mechanical abrasions are usually level with the surrounding surface and not depressed as in glanders.

DIAGNOSIS BY OTHER THAN PHYSICAL SIGNS.

It being so often utterly impossible to detect the existence of glanders in an animal by any of the signs heretofore described many other means have been devised and tried in order to determine if suspected animals be affected with glanders or not.

Finding early that the disease was transmissible to other animals by means of inoculation with the discharges from suspected animals, this means of arriving at a safe diagnosis suggested itself and considerable study was spent upon this subject in an effort to render this process reliable and convenient. Horses were tried as test animals but in these it was found unreliable, many of them being quite refractory to the disease, and in addition to the want of reliability the experiment animals proved too expensive.

Asses and mules were also tried, they being more susceptible to the glanders poison than horses, but these animals although somewhat more reliable were more difficult to obtain in many places and their value tended to prohibit their use. Then followed a long series of experiments with smaller animals including guinea pigs, rabbits, rats, mice and others, some of which responded promptly to the inoculation and appear to have yielded some practical results.

But in general the process proved unsatisfactory and troublesome delaying action in regard to suspected cases until the experimental inoculation had been tried, and besides, the inoculation was not practicable or convenient in most hands.

Even had inoculation in itself proven reliable, there are many cases of glanders in which there is no nasal or other discharge from which material can be obtained from the living animal for inoculation while it was found that in very mild cases of glanders the nasal discharges were very unreliable and produced the disease in comparatively few experiment animals.

The study of the pathological anatomy or structure of the diseased parts by Virchow, in 1855, gave new hopes of a basis for the safe diagnosis of suspected cases and it was attempted to practically diagnose the disease in the living animal by a microscopical examination of the enlarged lymphatic glands from between the jaws. Such means, however, were not available to most veterinarians and being rather impracticable generally, never came into common use.

The observations of Turn, Hallier and others in 1868 and the following years, in which they found in the blood and other parts of the body, a living bacillus, which was finally fully identified and proven as the sole cause of glanders by Loefler and Schutz, in 1886, gave the hope that microscopical examination of discharges or diseased tissues for the glanders bacilli, would prove a very valuable means for diagnosing obscure cases, but the mild ones, those for which some reliable test was desired, furnished comparatively few of the bacilli, rendering their detection very difficult and, besides, only a very few persons were capable of making a reliable microscopical diagnosis. The next and crowning discovery in relation to the diagnosis of glanders, based upon the discovery of the glanders bacillus of Loeffler and Schutz and suggested by the discovery of tuberculin by Dr. Koch was the discovery and preparation by Kalning and Helman of Russia, in 1891, of the product of the glanders bacillus known as mallein. This substance represents the poisonous products given off or formed during the growth of the glanders bacilli and is prepared by growing the germs artificially on potatoes, beef bouillon or other culture material and when the bacilli are well developed they are separated from the fluid by filtering and the fluid containing the poisons generated by the germs is then heated repeatedly to a temperature of about 120° C (248° F) and is either retained securely sealed in liquid form or is precipitated by means of alcohol and dried (dry mallein).

This substance when injected in proper amount into the system of a horse affected with glanders causes in a few hours (5 to 16) a marked rise in temperature, or fever, amounting usually to 2°C (4°F) or more, above the normal body temperature.

In acute or severe glanders we already have an elevation of temperature and in these we in some cases find no marked reaction but they are easily diagnosed without the aid of mallein, in the mild chronic cases we usually find no fever whatever, and it is in these we need the aid of mallein in arriving at a safe conclusion.

Our present knowledge of disease indicates that in glanders the bacilli themselves are not the cause of the chief symptoms in the acute or severe cases, but that they multiply in the blood and tissues to such a degree that the poisonous waste products given off by them, unless promptly thrown out of the system or destroyed, produce fever and other general symptoms of disease.

In the mild or chronic form of glanders these germ poisons are not formed so rapidly and the system soon becomes so accustomed to their presence and the means necessary for their removal, that they are carried from the body before they produce any change in the body temperature.

If then we add to the amount of this poison which the animal body is accustomed to handle and throw out without difficulty a small amount of artificially prepared mallein we create such a disturbance in the system of the animal as to cause the temperature to increase several degrees above the natural body heat, accompanied by usual symptoms of fever and aggravating for a time all the symptoms of glanders.

During the short time since the discovery of mallein it has been tested by leading scientific veterinarians in every part of the world, and, so far as I have been able to find, no investigator has condemned it, but all unite in asserting that its use has at least furnished us with an agent by which we can readily and safely diagnosis the disease, not alone in suspected cases, but in those animals where the most careful physical examination can detect no signs of disease.

Mallein has proven so reliable that it has received governmental recognition in many European countries and its use officially advised or commanded.

In cavalry regiments where glanders had broken out, the use of mallein on all exposed horses was made obligatory in Germany and Belgium in 1892 and in France in 1893. During the present year (1894) the use of mallein has been made obligatory in Switzerland in all horses, mules and asses, in stables or establishments where glanders has occurred, and in all cases of suspected glanders; and in all cases where the use of mallein is followed by a well marked fever and other characteristic results of the mallein test, the animal is destroyed after having been appraised.

The reaction or symptoms produced by mallein in glandered animals are well marked and highly characteristic. Preparatory to the test the temperature of the suspected animal is taken two or three times during the day prior to the trial, and a record of the temperature is again made at the time of injecting the mallein. The proper dose of mallein is then injected beneath the skin, usually along the neck, by means of an inoculating or hypodermic syringe. The spot where the injection is made is first cleansed by washing with a solution of corrosive sublimate or other antiseptic liquid and the needle of the syringe is carefully disinfected by immersing in such a solution or holding in a hot flame for a moment, until any forms of bacterial life which may exist in the needle are safely destroyed. These precautions are taken to render it certain that nothing but the pure mallein is introduced beneath the skin thus avoiding the danger of complicating or rendering valueless the trial. Subsequent to the injection the temperature of the animal is taken every two hours for 24 hours, and a careful record is kept of each measurement.

In animals suffering from glanders even in a mild degree, showing no outward signs, the temperature usually shows no particular change after the injection until after a lapse of five to eight hours and sometimes longer, when it suddenly rises as much as two, three or more degrees centigrade, above the normal body temperature, the highest point being usually reached eight to sixteen hours and sometimes later after the injection, after which the temperature slowly falls, reaching the normal again in twenty-four to thirty-six hours, or longer.

At the point where the mallein is injected the glandered animal usually shows a very considerable painful swelling, in many cases the animal becomes chilly as shown by shivering, the general appearance dull, the hair rough, appetite is lost, and in some cases any existing symptoms of glanders are aggravated, the nasal discharge if present before, may become increased, the glands more swollen and the ulcerations in the nostrils may increase in size and number. In other instances as will be seen later, especially in mild cases, no such evidence of increased disease action occurs. On the other hand animals free from glanders show none of the above symptoms in a marked degree after mallein injection, the temperature rarely increasing one degree C. if at all, the swelling at point of injection being small, soft, and not very painful to the touch, while the appetite and general appearance remains unaffected.

Other diseases than glanders do not affect the action of mallein, and it has been used on animals affected with distemper (or strangles), disease of the cavities of the face with abundant nasal discharge, botryomycosis (a disease similar to lumpy jaw of cattle, affecting at times the legs of horses like farcy) and other diseases resembling glanders, but in all cases the injection produced none of the results found in that malady.

Again it has been suggested that other substances of a similar character, such as tuberculin (the product of the bacillus tuberculosis or consumption germ) might produce the same results when injected into the system of a glandered horse, but experiments with tuberculin at least, contradict this view.

District Veterinarian Walther (1) of Saxony injected beneath the skin of each of three glandered horses, 0.3 c. c. each of tuberculin without producing a reaction while a like amount of the same tuberculin used upon a tuberculous cow produced the typical fever.

In rare cases the use of mallein on animals free from glanders has produced a decided elevation of temperature but not in the typical manner, for while in cases of glanders the fever usually reaches its highest point in from eight to twelve or rarely sixteen hours, in these rare cases of fever in animals free from glanders the high temperature is not generally reached until nearly or even more than twenty-four hours after its use. In cases of doubt where the elevation of temperature is clear, yet not so great as to clearly indicate glanders, a second or third trial may be necessary to determine if glanders exists. In some cases repeated injections of mallein increase, in other cases decrease the severity of glanders symptoms. Prof. A. Johne (1) of the Royal Veterinary school at Dresden tabulates the results of mallein tests upon 49 horses which had either been exposed to glanders or had shown symptoms which rendered them suspicious but not sufficiently definite, except in one case, to warrant a diagnosis of glanders. Of these 25 showed an increase of temperature of 1° C. (1.8° F.) or more, of which 20 were destroyed and found upon post mortem examination, glandered, the others upon re-testing were pronounced sound. Five animals somewhat suspicious before testing but showing no elevation of temperature, were destroyed and found free from glanders. The other animals remained apparently sound. Professors Hutrya and Preisz (2) of Buda Pesth, Austria, review 486 tests with mallein upon horses exposed to or suspected of glanders, of which post mortem examinations of 126 animals were made. Of this number 22 animals showed an elevation of temperature of less than 1.5° C. (2.7° F.), eight of which were found glandered, 13 free; 15 horses showed a reaction of 1.5° to 2° C., all of which upon post mortem were found glandered; and 89 animals reacted 2° C. or over, of which 84 were found glandered and five healthy. Of these five, one did not show the typical reaction described above, while in the other four the writers suspected serious errors either in the quality of mallein used or in the post mortem examination. H. Schindler, (3) chief veterinarian to the 7th Austrian hussars, after ineffectual attempts to stamp out glanders in his regiment by the ordinary means of destroying all those showing symptoms of the disease, used mallein upon 26 exposed horses, three of which reacted 2° or over, and after death, were found glandered. The three showing the next highest temperature, all less than 2° above normal, were found upon examination after death to be healthy.

---

(1) Deutsche Zeitschrift fur Thiermedicin, Vol. XIX, p. 173.

---

(1) Deutche Zeitschrift fur Thiermedicin, Mar. 1893.

(2) Ibid, Sept. 1894.

(3) Œsterreichische Monatschrift fur Thierheilkunde, July 1894.

Laquerrie (1) with Latour, records a test with mallein in an infected transfer stable in Paris containing 141 animals, but ten of which showed signs of glanders prior to the test. These ten, with 87 others which had shown no symptoms of glanders reacted to the mallein to the extent of 2° or over and upon post mortem examination the entire 97 were found glandered. Twenty-five of the remaining animals showing a fever of 1° to 1.5° after the mallein injection, were killed and found glandered while five others, showing no reaction, were found healthy upon post mortem examination and the remaining 12 showing no reaction remained sound. Nocard (2) of the National Veterinary School at Alfort, France, after trying in vain by rigid inspection and killing of all diseased animals found, to control glanders in a transport stable in Paris containing some 6,000 horses, finally resorted to the use of mallein and was surprised to find that several hundred animals showed fever after the mallein injection, scarcely any of which showed any signs of the disease before. All these were killed and post mortem examination showed them all to be glandered, many of them only to the extent of a very few small tubercles or nodules in the lungs, the nature of which was clearly proven by making pure cultures of the glanders germs from these nodules.

I. Neiman (3) speaking of the use of mallein in Russia gives a long list of investigators, all of whom fully agree to the great merit of this substance as a diagnostic agent in glanders. Dr. F. Boschetti (4) records a considerable number of experiments with mallein in Italy and pronounces it a thoroughly reliable test for glanders in all stages. Although less numerous, tests with mallein in the United States have proven quite as satisfactory as in Europe. De Schweimitz (5) and Kilbourne of the United States Bureau of Animal Industry cite 38 tests with mallein (mostly upon glandered horses) either by themselves or under their directions, in all cases proving wholly reliable, Dr. Pearson (1) Prof. Veterinary Medicine, Univ. Pa., experimented with mallein upon guinea pigs, some of which were healthy, others glandered; the latter reacted strongly.

---

(1) Ibid, March, 1892.

(2) Bulletin de la Societie Centrale de Medicine Veterinaire. 1892, P. 978.

(3) Revue Veterinaire, Nov., 1893.

(4) Œsterreichische Monatschrift fur Thierheilkunde. Aug. 1893.

(5) Proceedings United States Veterinary Medical Association, 1891-93.

Dr. Nuppe, in an unpublished paper, reports mallein tests upon about 300 horses in large establishments in New York city where glanders had long been prevalent, with the result that several cases of internal or masked glanders were found and destroyed, putting an end to the ravages of the disease in the infected stables.

In the brief time during which this station has existed it has not been practicable to arrange for experiments with contagious diseases at the station, so that our opportunities for making mallein tests have been upon farms where the disease existed, a condition which has necessarily restricted our experiments within very narrow limits. Our experiments with mallein were confined to two stables in which glanders had existed for some time and the mallein test was applied to eight animals. The results of these eight tests may be briefly summarized, as follows:

NO.	DATE.	AVERAGE TEMPERATURE DAY PREVIOUS TO TEST.	TEMPERATURE AT TIME OF INJECTION OF MALLEIN.	HIGHEST TEMPERATURE AFTER INJECTION.	NO. OF HOURS AFTER INJEC. WHEN HIGH'ST TEMPERATURE OCCURRED.	INCREASE OF TEMP. IN DEG. CENTIGRADE.
1	Feb. 17 1894	37.2	36.7	39.7	12¼	3.0
2	" " "	37.9	36.2	39.7	10	3.5
3	" " "	36.9	37.3	40.2	10	2·9
4	" " "	—	36·9	38.0	10	1.1
5	" " "	—	36 9	39.0	12¼	2 1
6	July 3, 1894	38.3	37.7	40.6	12	2.9
7	" " "	38.2	37.5	39.7	12	2.2
8	" " "	38.1	37.3	38.4	12	1.1

Nos. 1, 2, 3 and 5 were all clearly affected with glanders and so pronounced before using the mallein. As will be seen all showed a reaction to mallein of not less than 2.9° C (5.22° F.). No. 5 showing a reaction of 2.1° was apparently well and so continues, which may be accounted for by an accident in injecting the mallein, the day being so cold that the mallein froze in the syringe, rendering the dose uncertain and no opportunity has occurred to make a second test. No. 5 has at no time shown signs of glanders, although the reaction clearly denotes that she is affected. She is the mate to, and was driven with No. 5, until the latter became seriously affected with glanders, when they were separated and both are still under observation. Nos. 4 and 8 remain sound.

---

(1) Journal Comparative Medicine. Sept., 1891.

The foregoing observations upon the employment of mallein form but a part of the great number of records of its use and serve only to illustrate its great value in diagnosing glanders. Its use under proper precautions is almost wholly without danger of error and places in the hands of veterinarians for the first time a reliable agent for determining promptly the existence or absence of glanders in suspected or exposed animals. The preparation and use of mallein is constantly becoming better understood, so that the errors made in its use at first, are now mostly understood and avoidable, The mallein test possesses a double value discovering unsuspected cases of glanders and freeing from suspicion animals affected with other diseases similar in appearance to glanders.

GLANDERS IN OTHER ANIMALS.

We have already had occasion to say that glanders had been recorded in all domesticated animals except cattle and in a number of wild animals in captivity. Of all domesticated animals, mules and asses contract glanders most readily and suffer most severely so that a horse affected with mild or masked glanders introduced into a band of mules, while retaining his general appearances of health causes the disease to spread rapidly and in a very fatal form among the mules, the real cause of the fatality frequently remaining for a long time unsuspected. It is very difficult to induce the disease in the sheep or goat and practically never occurs in them except by experimental inoculation and then they suffer but little from it as a rule. In carnivora it is more readily induced than in cattle, sheep and goats, and has been seen in dogs, cats, lions, tigers, panthers and other flesh eaters. Among rodents it is easily induced by inoculation in rabbits, Guinea pigs, rats and mice and in a very severe form. It is doubtful if the disease ever exists in the pig. The symptoms in all these animals are essentially the same as described in the horse.

GLANDERS IN MAN.

Human glanders has been recognized for nearly a century as one of the most loathsome and fatal of diseases. It is usually contracted from the horse or mule by accidental inoculation in wounds, and consequently happens almost wholly among those who have the care of horses, and is therefore most common in man, in those countries where it is most prevalent in horses. A large proportion of glandered horses are doctored under the direction of some neighborhood or travelling quack regardless of the jeopardy in which it places the attendant's life and it is only from the fortunate fact that man does not readily contract the disease that more people do not perish from it. The disease in man naturally is contracted most frequently from horses suffering in a mild form as these are handled and doctored without suspecting the nature of the malady, while severe cases are usually shunned; thus in southern Russia where glanders in horses is both very common and mild it is quite prevalent in man. In the district of Berdian, Russia, fifteen cases were reported in 1891, and twenty-nine in 1892-93 mostly among the agricultural classes who do not fear the disease.. The apparent increase in the number of cases in man is suspected to be due rather to increased knowledge of the disease on the part of physicians who recognize the true nature of more of the cases of glanders coming under their care. In Roumania with a climate similar to southern Russia the disease is quite frequent in man. In those countries where the disease is more severe in horses, and veterinary police laws against glanders in animals are enforced, it is less common in man, probably a majority of cases passing unrecognized, their rarity throwing the physician off his guard. It occurs occasionally in all sections of the United States, and although occurring in man in Montana no statistics are available to show it to be more or less common than in other states. The symptoms are essentially the same as those noted in the horse, the severe form beginning with high fever, chills, discharge from the nostrils with ulcerations, inflammation of joints and of lymphatic glands, (farcy buds,) cough, difficult breathing, inflammation of the lungs, etc., and from this severe form there is every gradation to the mild chronic or even internal or masked form. Dr V. Babes, Bucharest, Roumania, records a case in man, who as a groom, had cared for a glandered horse, sickened apparently of pleurisy, seemed to recover, went to work in an oxherd, and after being away from horses for six years, sickened and died of glanders, the post mortem examination showing the presence of old glanders lesions or changes which had occurred at time of pleurisy, thus showing that in man as in the horse, the disease may exist for a long time in an unrecognizable or masked form.

CAUSES OF THE PREVALENCE OF GLANDERS AMONG MONTANA HORSES.

No intelligent stockowner would knowingly retain a glandered horse among other healthy animals or permit it to be handled by men so as to endanger their lives, consequently glandered horses exist chiefly because it is not recognized by the owner owing to its very mild or wholly unrecognizable character. We thus find glanders most common in those countries where it is mildest in character. Such is the case in Montana and other Rocky Mountain states, where glanders runs a very mild course and being unrecognized by horse-owners the affected animals are allowed year after year upon the same range, or kept in the same stable with healthy horses, the disease spreading slowly but surely until at present, although our climate is such as to render the disease far less virulent than usual, it has become common. The scarcity of qualified veterinarians, by leaving most all animals to the care of persons not versed in animal diseases, tends also to increase the prevalence of glanders and the inferior value of a large part of the horses themselves secures for them scant care, and running in a wild state upon the ranges are rarely closely inspected by owners or others, and even if known to be diseased are of too little value to attract attention. Glanders is pre-eminently a disease of cheap horses, in part because they are not worth looking after when diseased, and in part because their owners are frequently careless even against their interests.

TREATMENT.

In most countries the treatment of glanders is prohibited by law, and instead, the control and eradication of the disease is sought by compulsory quarantine, slaughter and disinfection. Its treatment has, until very recently, rarely been undertaken by qualified veterinarians, except as an experiment, while quacks and owners, ignorant of the nature of the disease, have been profuse in their efforts to cure the disease, it, in the meantime spreading to other animals. All kinds of drugs and nostrums have been used by these persons with the only result, if any, of causing a temporary improvement of symptoms rendering it all the more dangerous because unrecognizable. The curability of glanders has long been a vexed question, a few veterinarians holding that many cases were curable, while the majority held that all cases were positively incurable and surely fatal and between these two extremes every grade of opinion was held. These views have been modified largely by the character which the disease assumed in the particular country in which the veterinarian giving the opinion was located, so that those seeing the disease in countries like southern Russia, Roumania and Italy, where it is very mild, have been the most confident of its curability. With our increased knowledge of glanders and other infectious diseases the idea of a positively fatal contagious disease has well nigh disappeared and it is now quite generally admitted by leading veterinarians that some cases of glanders recover either spontaneously or under treatment.

Dr. Fleming, (1) late chief veterinarian to the British army, held several years ago that possibly some rare cases of farcy of a mild type and in the first stage might be cured, and lately (2) in the light of our present knowledge of the disease admits the possibility of recovery in a much greater number of cases. Prof. Williams, (3) principal of the New Veterinary College, Edinburgh, admits the possibility of recovery in mild cases of farcy. Prof. F. Friedberger of the Munich Veterinary school and Prof. E. Frohner (4) of the Royal Veterinary College at Berlin assert that rarely glanders is curable, an opinion shared by Prof. Dieckerhoff (5) also of the Royal Veterinary School at Berlin, who relates an instance of recovery from glanders occurring in his practice. Prof. E. Nocard (6) of the National Veterinary School at Alfort, France, gives the opinion that the use of mallein as heretofore described for diagnostic purposes not infrequently works a cure. Dr. E. Semmer, (7) chief of the epizootic department of the Royal Institute for Experimental Medicine at St. Petersburg, states that Decroix and Bouzom in Algiers cured numerous cases of farcy, while Brusaco, Tollovio and Saltella of Turin, Italy, report having cured 25 to 50 per cent. of cases of glanders and Neumann in the Caucasus, Haubner, Bollinger of Munich and others report successful cures.

With Itzkovitsch, Prof. Semmer observed at Dorpat, Russia, the spontaneous recovery of a severe case of glanders which had been induced by experimental inoculation.

Mercury and iodine have both been used in Russia with apparent success in glanders of horses and man, but Prof. Semmer regards mallein as giving the greatest promise of a fairly successful curative agent, using it in a similar manner to that already described for diagnostic purposes, and in this connection states that with this substance, Pilavios, principal veterinary surgeon to the Greek army, cured eight glandered horses, and Helman of Dorpat, Russia, three glandered horses and one ass, their cure having been tested, the animals being thereafter proof against inoculations with virulent glanders matter and showing no reaction to mallein. With blood serum from these horses Prof. Semmer rendered cats and guinea pigs proof against glanders. Leblanc (1) asserts that certain forms of glanders are curable by the use of mallein.

---

(1) Veterinary Sanitary Science and Police, Vol. I., P. 505.

(2) Veterinary Journal, Oct., 1894.

(3) Williams' Principles and Practice of Veterinary Medicine.

(4) Friedberger und Frohner. Lehrbuch der Speciellen Pathologie und Therapie.

(5) Dieckerhoff's Lehrbuch der Speciellen Pathologie und Therapie. Vol. 1, P. 154.

(6) Deutsche Zeitschrift fur Thiermedicin, Sept, 1894.

(7) Ibid "Neber gutartige heilbaren Formen des Rotzes." Dec. 1893.

V. Babes (2) Professor of Experimental Pathology, Bucharest, Roumania, after noting a long series of cases of unrecognizable or masked glanders in horses and their recovery, spontaneously or with the use of mallein, says: "The unsuspected frequency of masked and latent glanders in horses, and the fact that spontaneous recovery takes place in a large number of cases of the disease—the possibility of which has been denied by most investigators, but must, nevertheless, be looked upon as the rule, for otherwise half the horses would die from glanders in certain countries—suggests the question whether the glanderous infection in other animal species, and more particularly in man, does not present the same peculiarities as those I have just described." Prof. Bonome (3) of the University of Padua, Italy, records the successful treatment of glanders in horse and man by the use of mallein. Prof. LeClainche (4) of the veterinary school at Toulouse, France, says: "There is nothing fatal in glander infection, on the contrary a large number of animals resist it and the lesions already developed cicatrize (heal). It is established that glanders may disappear in the absence of all treatment."

It should be noted that nearly all the above cited cures from glanders are reported from the most southerly portions of Europe, where the disease is of a very mild character, resembling in all essential particulars the type the malady usually assumes in Montana and other Rocky Mountain states, in which region several veterinarians have seen apparent recoveries from this affection, and where it not rarely happens that animals pronounced glandered by veterinarians, apparently recover and remain sound so far as can be seen, frequently leading the owner to believe that an error had been made and that the horse had in reality been affected with some other less serious disease.

---

(1) Œsterreichische Monatschrift fur Thierheilkunde July 1893.
(2) Veterinary Journal, Vol. XXXIX, p. 266,
(3) The Veterinarian, Vol. LXVII, p. 751.
(4) Veterinary Journal, Vol. XXXIX, p. 2.

It is not uncommon to see in this state animals clearly affected with glanders which, according to the observations of the owner, have evidently been affected for five, six or more years, retaining at all times the general appearances of good health, part of the time free from any glanders symptoms and constantly able to perform ordinary work, showing in every way a strong tendency to recover.

In one case now under observation, known as No. 6 in the table on page 104, apparent recovery from acute glanders has taken place in a few months, without treatment, while in No. 7 of same table, glanders is clearly present according to the mallein test, the animal showing otherwise every evidence of robust health. It consequently seems probable that spontaneous recoveries from glanders take place among Montana horses, especially among those living wholly free and practically wild upon the high ranges.

Although most modern investigators admit the curability of some cases of glanders, these recoveries are confessedly few and the treatment of the malady, whether by medicines or mallein, is yet purely experimental, unworthy of confidence from a practical standpoint, yet pointing hopefully toward reliable treatment in the near future. Apparent recoveries from glanders are unfortunately too often apparent only, and serve to continue the spread of the disease.

A horse apparently recovered from glanders is worthy of being regarded with very great suspicion, and his apparent recovery should not be accepted as real until satisfactorily tested with mallein, and the treatment of glandered animals, except experimentally, by competent investigators, should be prohibited until further knowledge is obtained upon the subject.

IMMUNITY.

As in most contagious diseases, animals which have recovered from glanders are proof against future exposures to the malady.

Injections of virulent glanders matter under the skin of a recovered animal may cause a local abscess at the point of injection, which heals rapidly, but it seems impossible to cause, by inoculation, a general glanders infection after recovery.

CONTROL AND ERADICATION.

The mild character which glanders assumes in Montana and the consequent possibility of a cure in some cases does not warrant less vigorous means for stamping it out than were it severe and fatal, but its mild and often unrecognizable character tending constantly to increase its spread unobserved, the very considerable losses it constantly entails upon owners, the menace to the health of man and the fact that cases of masked or latent glanders shipped to the markets upon which we must depend for the sale of our surplus horses, and there put to work, quickly develop the disease in a severe type, all serve to make it as important that Montana should be free from glanders as that other states should be free. It is important, too, that its eradication should be pushed as early and vigorously as possible while it is confined as at present, chiefly to the poorer grades of horses, while the better bred and cared for bands are rarely infected. Whenever symptoms of glanders are observed in a stable or band of horses the state veterinary surgeon should be promptly notified and an inspection of all suspected or exposed animals made by him, those evidently glandered destroyed, those suspected or exposed tested with mallein and those found to react, destroyed, the carcasses deeply buried or preferably burned, the stables disinfected and the disease promptly stamped out.

A serious obstacle to the eradication of glanders in Montana is the vast number of worthless range horses, the present value of which would not repay the trouble and expense of a mallein test, yet they constantly menace the health of our better bands and constitute an expensive nuisance to the state from whatever standpoint viewed. The breeding of fewer and better horses should be encouraged, and some means devised for the destruction of the worthless animals.

In the investigation, control or eradication of this and other diseases of live stock in Montana, this station, through its veterinarian, wishes to heartily cooperate with stock-owners generally, and render any assistance possible.

EXPLANATION OF ILLUSTRATIONS.

FIG. I. Nasal partition from an aged Montana range mare said to have been glandered four or five years, during which time she had shown slight discharge from the right nostril and considerable swelling of right submaxillary gland. Otherwise she appeared in good health.

A. Recent glanders ulcers, with ragged, ulcerating edges.

B, Old ulcerated patch which has healed, leaving a wrinkled scar. The reverse side of this septum, which is healthy, is represented in Fig. IV.

FIG. II 1. A portion of one of the turbinated bones, and 2, the nasal partition from a 3-year-old Illinois filly affected with glanders about one year. At A in 1 are seen several solitary glanders ulcers. The entire surface of 2 has been destroyed by the confluence (running together) of innumerable ulcers which at B have penetrated so deeply that they have pierced the septum from side to side so that a man's finger could be passed through the partition from one nostril into the other. At A is seen an old adhesive band, the result of glanders ulceration, which united the nasal partition to the outer nostril wall. The septum shows throughout, a tendency to heal

FIG. III. Nasal partitition from an aged Montana ge'ding, kept mostly on the range, at times worked upon a farm, said to have been affected for four or five years, his mate being more severely affected during the same period. At A are seen three small ulcers, and at B a dark colored but otherwise apparently healthy spot the nature of which is unknown. No scars from previous ulceration are to be found, doubtless because they, like those seen at A, have all been small and very superficial.

FIG, IV. The left side of Fig. I, showing the apearance of a healthy septum or nose partition.

FIG. V. Nasal partition from a 3-year old Montana farm gelding, affected with acute glanders for a few weeks. Both sides were affected alike, the entire surface of the partition being one continuous mass of ulcerating, sloughing tissues, the gangrene or death of the parts, extending deeply at A so that had the animal lived a few weeks longer the partition would have been perforated as in Fig. II.

FIG. VI. Nasal partition from an aged Illinois gelding affected with acute glanders of a few months. From A to A along center of partition is one continuous ulcerating patch, while on either side are smaller ulcerating patches interspersed with healthy patches. Opposite side is wholly free from ulceration.

FIG. VII. Nasal partition from a 4-year-old Montana farm gelding, affected with glanders about one year, At A are shown, two large wrinkled scars, the seat of former ulcerating patches. At B are seen several recent ulcers.

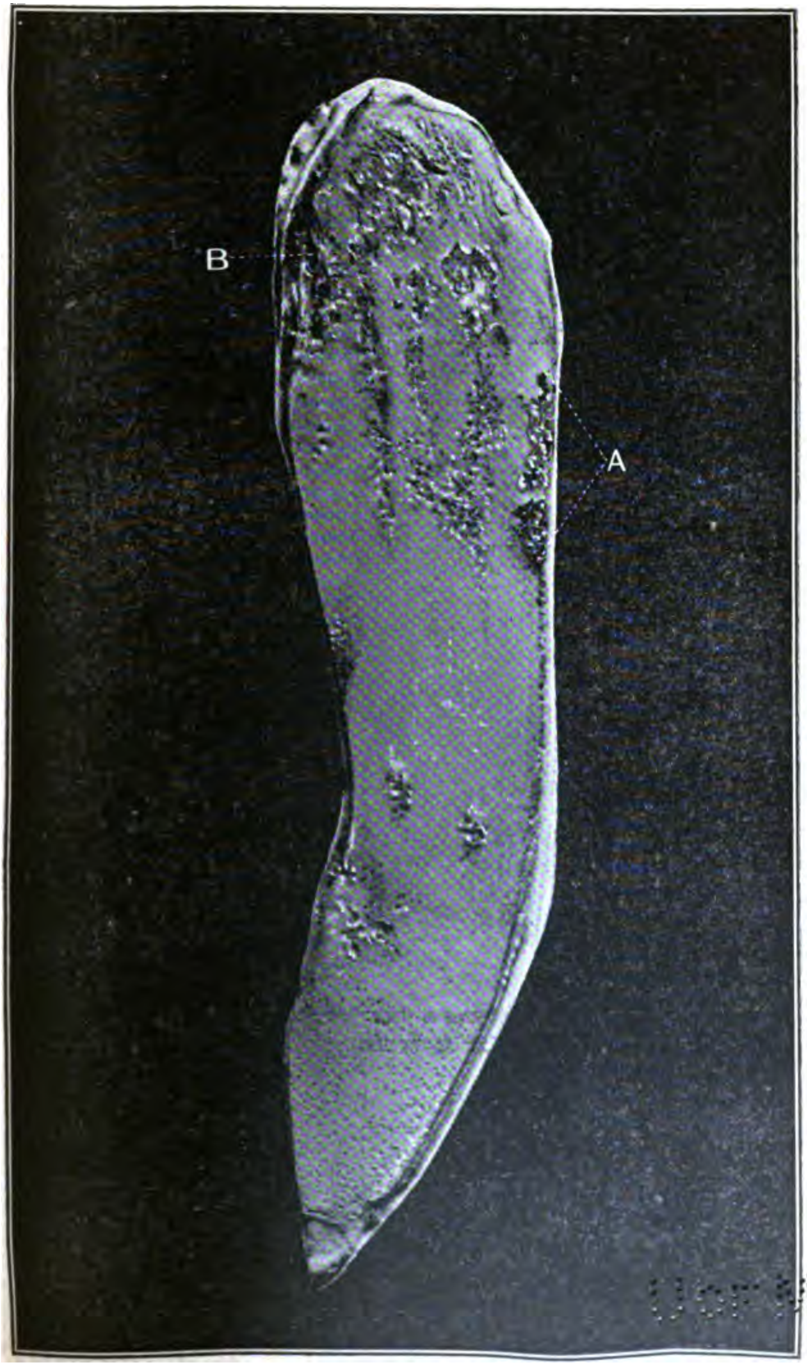


FIG. I.

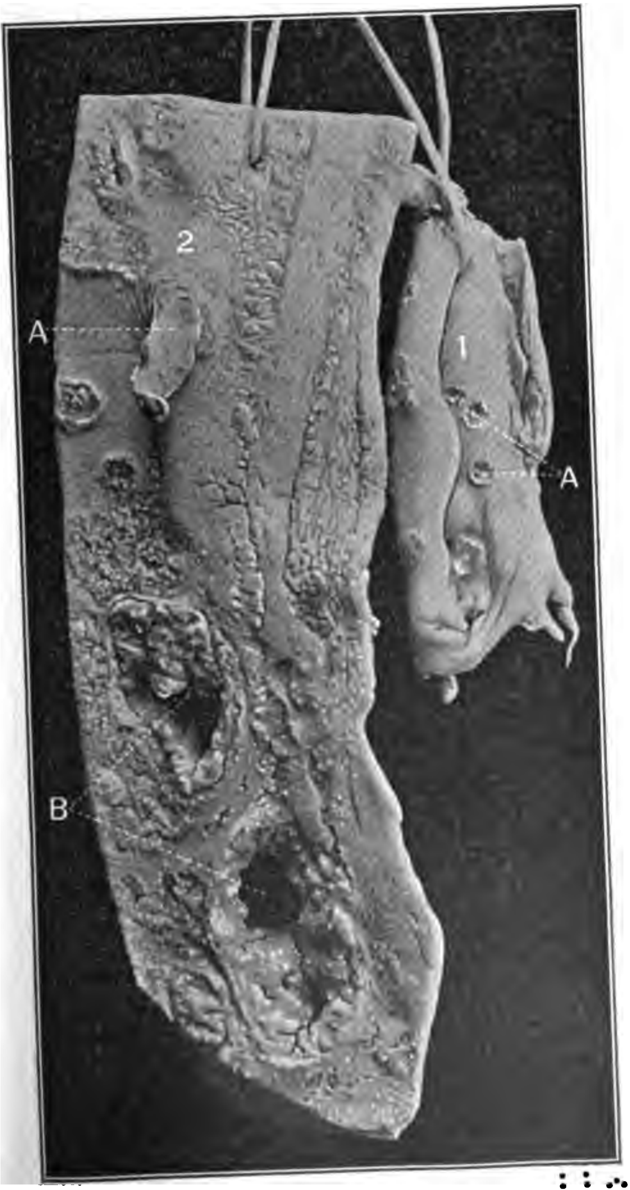


FIG. II.

U of M

MToU

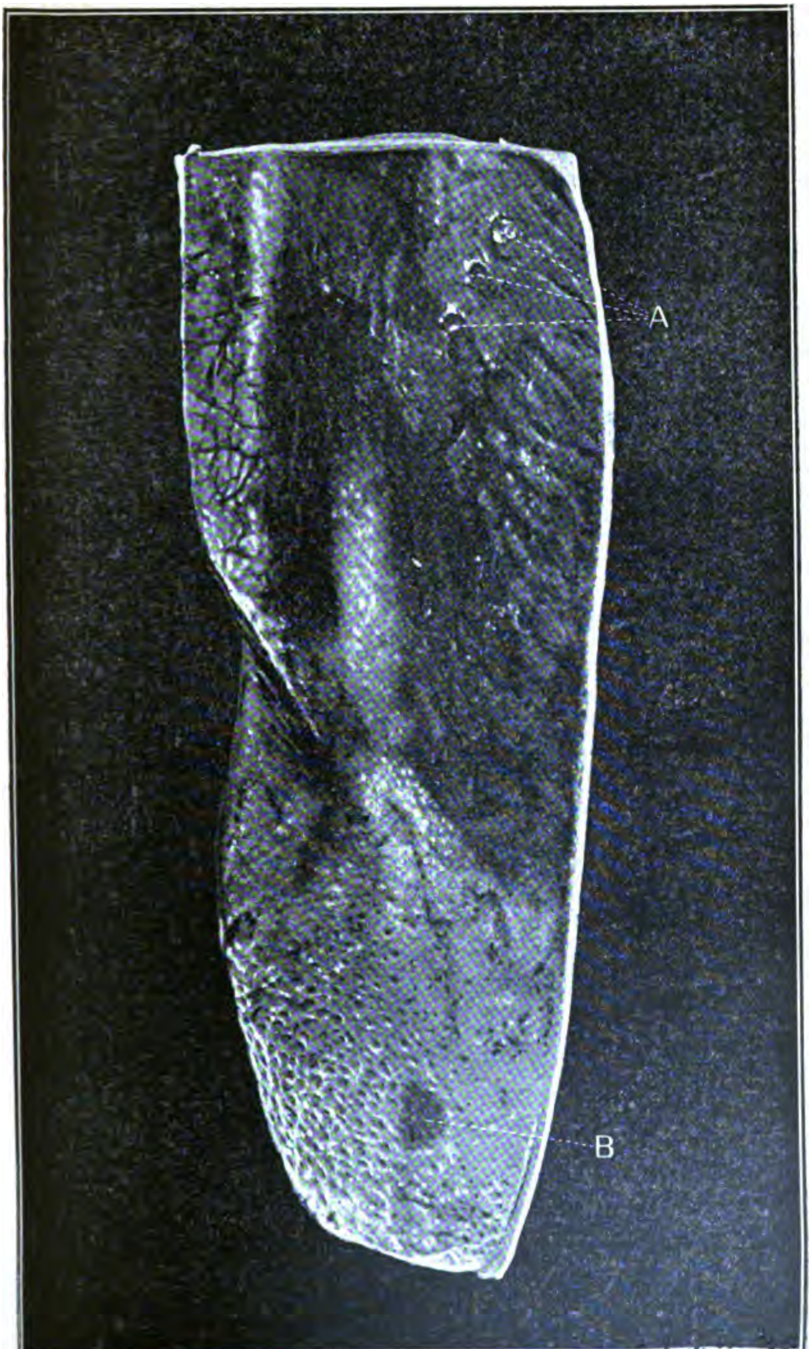


FIG. III.

MTOU

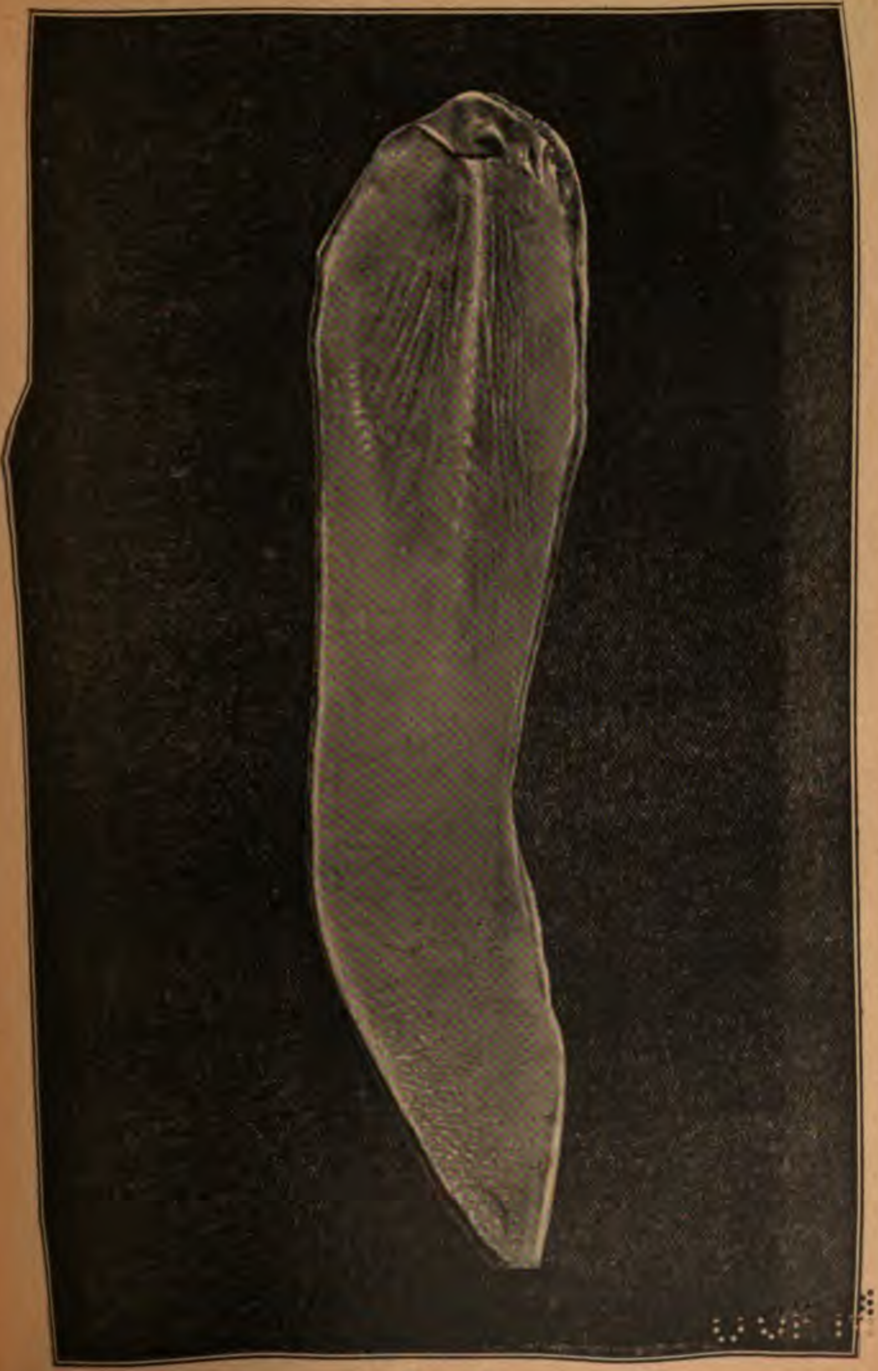


FIG. IV.

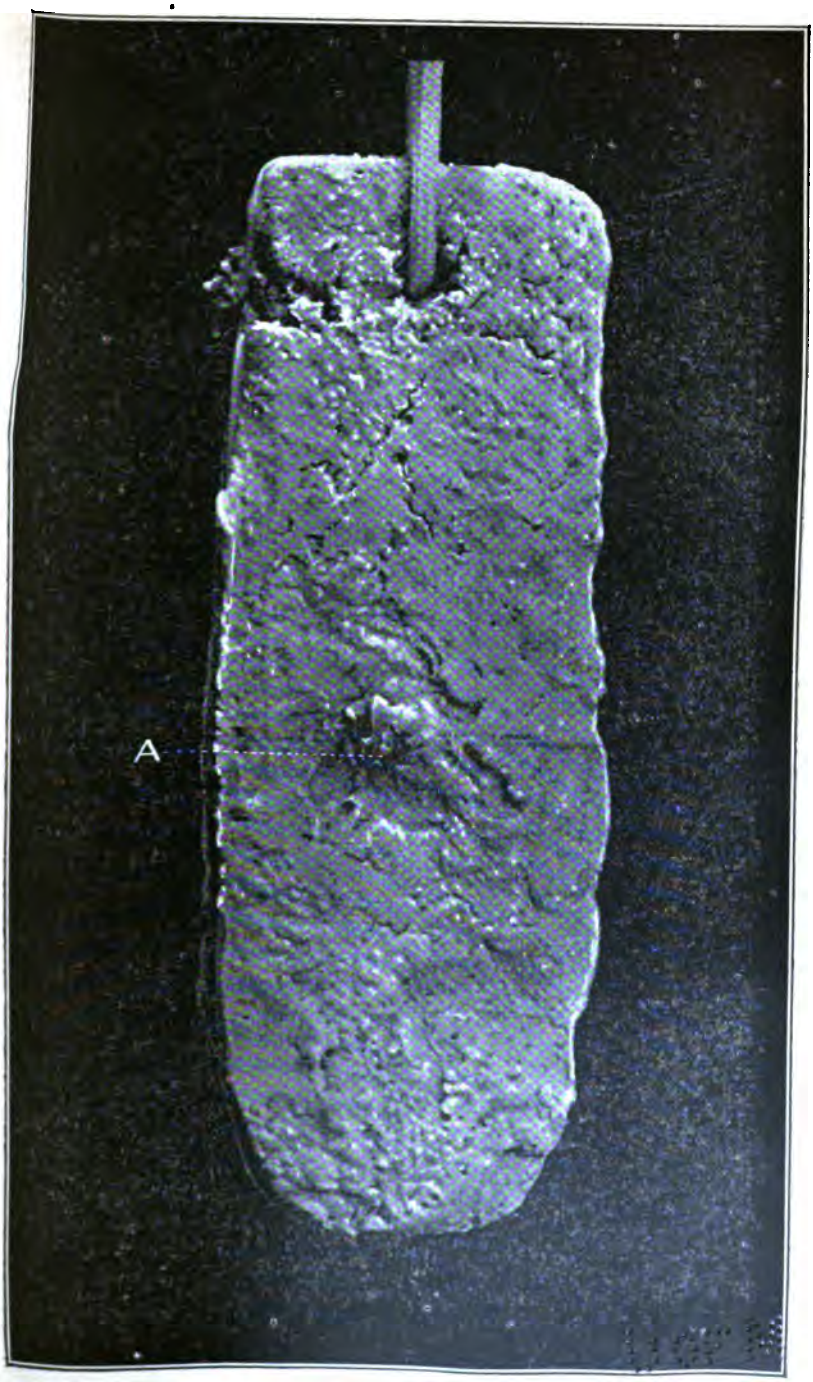


FIG. V.

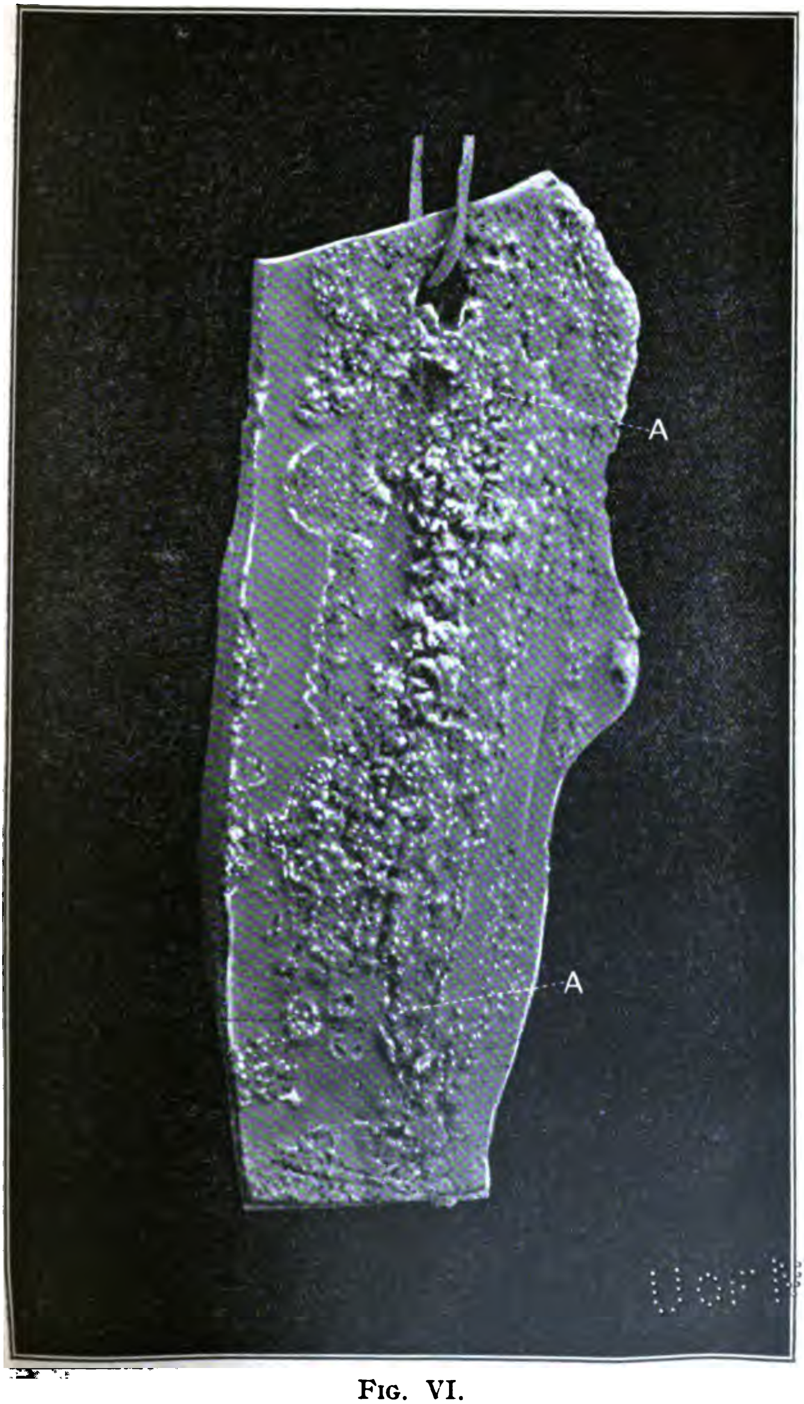
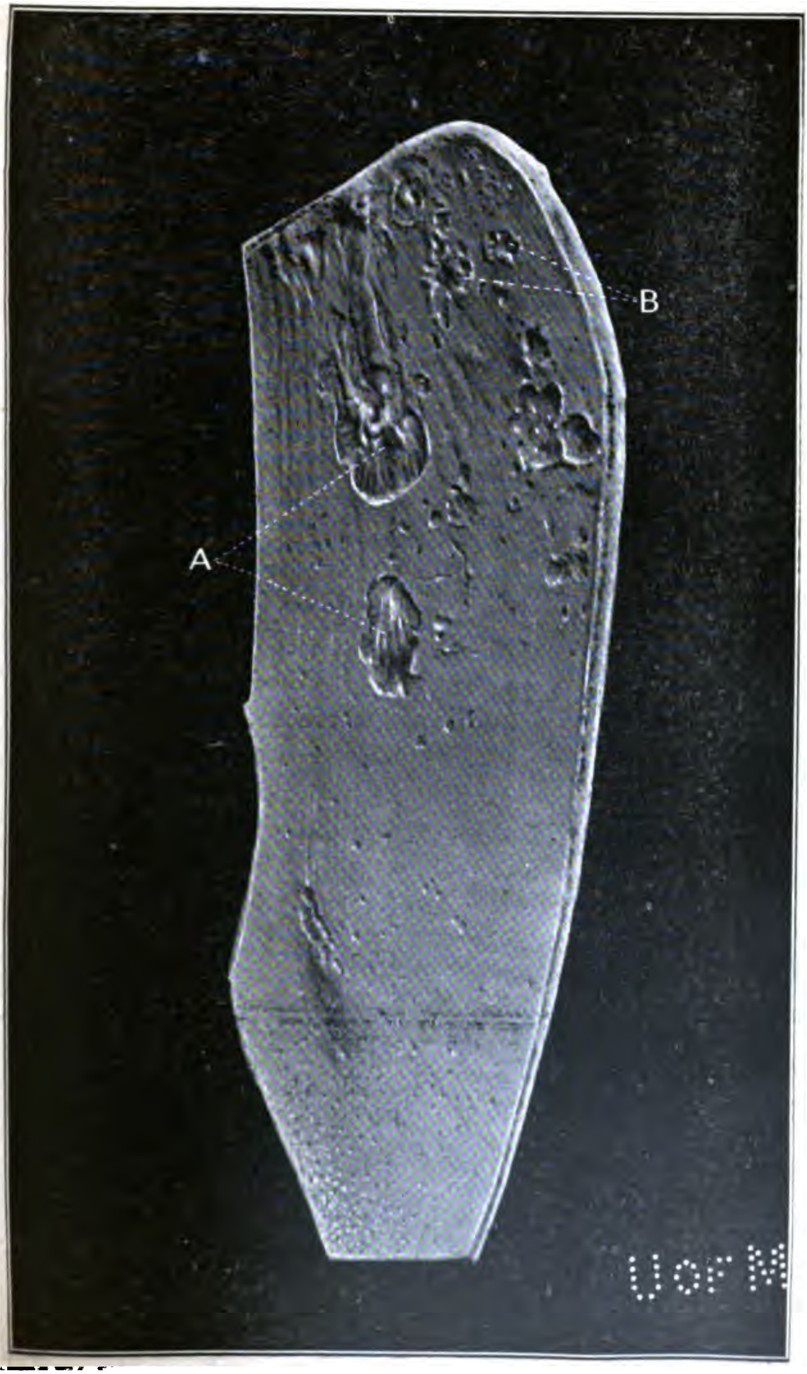


FIG. VI.

KTOU



U of M

FIG. VII.

NTOU

30,679
M9 ab

UNIV. OF MICH.

BULLETIN NO. 5.

MONTANA
AGRICULTURAL
EXPERIMENT STATION

FIRST ANNUAL REPORT

. . . . OF . . . .

Treasurer, Director, Agriculturist,
Chemist and Veterinarian,

. . . AND . . .

CROP STATISTICS OF GALLATIN COUNTY, MONTANA.

BOZEMAN, MONTANA, FEB'Y 1, 1895.

Bozeman Chronicle,
Book and Job Printers.
1895.

MONTANA AGRICULTURAL

EXPERIMENT STATION.

LETTER OF TRANSMITTAL.

BOZEMAN, MONTANA, February 1st, 1895.

To His Excellency, John E. Rickards, Governor of Montana:

DEAR SIR: I have the honor to transmit to you herewith in accordance with law, the first annual report of the Montana Agricultural Experiment Station.

Respectfully,
S. M. EMERY, Director.

EXECUTIVE BOARD.

LESTER S. WILLSON, President	Bozeman.
PETER KOCH, Secretary and Treasurer	Bozeman.
GEORGE KINKEL, JR., Vice President	Manhattan.
WALTER COOPER	Bozeman.
E. H. TALCOTT	Livingston.

EXPERIMENT STATION STAFF.

S. M. EMERY	Director and Horticulturist.
LUTHER FOSTER, M. S. A	Agriculturist and Botanist.
F. W. TRAPHAGEN, Ph. D, F. C. S	Chemist.
W. L. WILLIAMS, V. S	Veterinarian.
A. M. RYON, C E	Irrigation Engineer.

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

MONTANA EXPERIMENT STATION,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Report of the Treasurer of the Board.

The Montana Experiment Station in account with the United States Appropriation, 1893-94.

Dr.

To	receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1894, as per Act of Congress approved March 2, 1887	$15,000 00

Cr.

By	Salaries	3,499 54
	Labor	1,481 18
	Publication	247 75
	Postage and Stationery	295 70
	Freight and Express	491 26
	Heat, Light and Water	320 78
	Chemical Supplies and Scientific Apparatus	1,930 36
	Seeds, Plants and sundry supplies	155 71
	Feeding Stuffs	320 06
	Tools, Implements and Machinery	836 84
	Furniture and Fixtures	655 83
	Live Stock	716 30
	Traveling Expenses	160 24
	Contingent Expenses	227 25
	Fence	661 20
	Building and Repairs	3,000 00
	Total	$15,000 00

I hereby certify that the above is a true and correct statement of the receipts and expenditures of the Montana Experiment Station for the fiscal year, ending June 30, 1894.

PETER KOCH, Treasurer.

We the undersigned, duly appointed auditors, certify that we have examined the above account and find it correct. Dated at Bozeman, Montana, this 23rd day of January, 1895.

LESTER S. WILLSON,
WALTER COOPER.

ATTEST: PETER KOCH, Secretary.

Montana Experiment Station.

Bulletin No. 5. ◆◆◆ **February 1, 1895.**

Annual Report of the Director, for the Fiscal Year Ending June 30, 1894.

ORGANIZATION.

The Montana Experiment Station was established by an act of the Third Legislative Assembly of Montana, under date February 16, 1893; the official existence of the station began July 1st, 1893.

STATION STAFF.

The following were elected members of the station staff by the executive board and duly confirmed by the state board of education:

S. M. Emery, Director and Horticulturist; Luther Foster, Agriculturist and Botanist; F. W. Traphagen, Ph. D., Chemist; W. L. Williams, V. S., Veterinarian.

STATION FARM.

A better selection of a site for the experiment farm could not have been possible, comprising a quarter section of land, every foot of which is susceptible of cultivation. It is situated adjoining the city limits, within 4,000 feet of the business center of Bozeman. The two main highways of the county leading out from the City of Bozeman, and into the famous Gallatin valley, pass, one on the north, the other on the south side, of the farm; the electric street car line starting from the passenger depot of the Northern Pacific railway, passes within a block of the grounds on the east, and the proximity to these main thoroughfares places the farm under the direct observation of the largest body of agriculturists within the state, while at the same time those from abroad are offered the best possible opportunity to visit and inspect the station.

The farm was naturally a fertile tract, but its management for the ten years prior to state ownership has been of the poorest.

The cultivation has been slovenly in character, the soil has been impoverished by injudicious cropping and it is infested with wild oats and sunflowers.

The improvements on the farm were almost worthless, the fences old and decayed, the stables built of logs, were dilapidated, and the farm house, of frame structure, was poorly constructed and illy arranged.

These conditions, however, offer an excellent opportunity to formulate and execute a policy in improvements as will be an object lesson and a pattern to the Montana farmer in improving his farm, while the foul condition of the fields will afford an immediate lesson to the agriculturist in the extermination of noxious plant growth; which is too often to be seen in the fertile fields of the irrigated region, and the bringing back to the state of original virgin fertility of the farm soil, will be a no less valuable experiment to the interested agriculturist.

Aside from structures that will be used strictly for scientific experimentation, it is our opinion and will be the policy of this station, to erect only such buildings for farm purposes as will serve as desirable models to the ordinary farmer.

BUILDINGS.

Plans have been adopted and a contract let, and the construction well under way, of a station building 45½x50 ft., stone foundation, brick veneer, to consist of a basement, two full stories and a capacious attic, plain but substantial in character, to cost $3,516.00.

A combined poultry house and machine shed 25x48 ft., has been erected at a cost of $234.00.

FENCES.

The farm has been enclosed with a substantial, durable fence, of the following materials.

Red cedar posts, round, seasoned, peeled, sawn square top and bottom, planted 28 inches in depth, one rod apart, double thick set galvanized barbed wire, five strands, best quality.

FERTILIZERS.

Six hundred and thirty-six loads of stable manure have been spread on the poorest soil at the rate of 40 2-horse loads to the acre, six acres were sown to alfalfa, four acres to red clover, six acres to Irish potatoes, with clean culture, and six acres to field peas. It is proposed to use a judicious system of crop rotation, of crops nitrogenous in character, of green manuring, combined with hoed crops under clean culture, and the application of all the manure that can be procured during the winter season, rather than the summer fallow system now in general use in this valley.

EXPERIMENT PLATS.

Aside from the plan of treating the entire farm experimentally, ten acres have been devoted to plats for experimentation, ranging in size from the tenth of an acre, to those requiring a pound of seed in sowing. This is situated in the most prominent part of the farm, is intersected by a broad drive way, at each end of which are gates, and in the county papers have been published invitations to the farmers to pass through and inspect.

The accompanying report of the Agriculturist will state the nature of crop experimentations.

LIVE STOCK.

A span each, of heavy draft mares and geldings have been purchased for farm use, one of the latter died in April and has been since replaced.

The poultry house has been stocked with desirable fowls of the following varieties:

Brown Leghorns, Plymouth Rocks, Partridge Cochins, and Bronze Turkeys.

CROP STATISTICS OF GALLATIN COUNTY.

Desiring to know what had been accomplished in farming operations, the detached card was mailed to each owner of farm lands in this county (950 in number) and their answers have been collated, thus giving the station an intimate knowledge of previous farm results, very valuable in many ways:

OFFICE MONTANA EXPERIMENT STATION.
BOZEMAN, MONTANA, October 1st, 1893.

DEAR SIR: This Station believes that the Gallatin valley is one of the very best agricultural districts in the world, and for the purpose of confirming this opinion, we ask that you fill out the card hereunto attached, with answers to each question, at your earliest opportunity.

Detach the card that is to be returned to us, from this card and mail to the Station. These cards go to each farmer in the valley and we expect general replies from all. When received they will be properly collated and published, and will be placed in the hands of thousands of readers through the instrumentality of the railroads. The benefits will be of great value to this section, and speedy replies are therefore expected.

We realize that this has been a trying year, on account of unseasonable weather, but please get to this as soon as you have threshed and it will be duly appreciated.

Yours truly,
THE DIRECTOR.

How many acres of land do you cultivate?........................
How many acres of pasture land? ....
How many acres under irrigation?..............................
How many inches of water are you entitled to use?..................
How many inches of water do you use to the acre?................
How many acres are seeded down?
How many acres of alfalfa?........
How many acres of oats?..........
What was the yield per acre?.....
How many acres of wheat?........
What was the yield per acre?.....
Variety of wheat sown?...........
Yield winter wheat?..............
Yield spring wheat?..............
Has hard wheat developed into soft wheat under irrigation with you?.......................... ....

What varieties of tame grasses are your meadows?..............................
..
What is the average per acre of tons of hay?..........................
How many crops of hay do you cut per season?..........................
..

Acres barley?..........................
Yield per acre?..........................
Acres of peas?..........................
Yield per acre?..........................
Acres of potatoes?..........................
What varieties of potatoes?..........
..
What was the yield?..........................

Sign Name..
Post Office Address..

The Gallatin valley farm averages in size 196 acres.

Two and one-ninth inches of water is used per acre in irrigation; this lavish use is owing to the habit of flooding hay meadows, both previously and subsequently to hay harvest.

Cereals average per acre as follows: Oats, 54 3-5 bu.; wheat, hard spring, 32 1-2 bu.; wheat, winter, 39 bu.; barley, 44 1-3 bu.

The general average for hay per acre, 1 2-9 tons, peas, 23 1-2 bu., and for potatoes, 263 8-9 bu. per acre. Forty-six different varieties of potato seed were used, with but little regard to size, shape, color or season. It is impossible under this system to secure straight varieties for shipment, and the grower suffers serious loss on this account. Early ripening varieties, white in color and medium in size, command the best price in eastern markets.

FARMERS' INSTITUTES.

Pending the time when the growing duties of the station and college would engross the entire time of the station staff (all of whom are employed in the dual capacity of experimentors and instructors) it was deemed advisable to conduct institutes.

Forty-nine meetings in all, were held, in some of the most promising agricultural sections of the state.

The attendant expenses have been borne by the respective communities, a burden most cheerfully assumed, in order to secure the services of the staff.

The interest in our work and the feeling shown to the station by the farmers, and the Press of the State is the most kindly and cordial in character, and the usefulness of the

Institution, can but be greatly augmented by the promised and performed hearty co-operation of those most interested in its operations.

PRESS COMMUNICATIONS.

Aside from the business correspondence of the various departments which is rapidly increasing, and the editing of the bulletins of the station, there is a great and growing demand upon the staff for communications for publication for newspapers and magazines, both within and without the state.

This service is always most heartily rendered to the best of our ability.

NEWSPAPER AND MAGAZINE EXCHANGE LIST.

The Station is pleased to call attention to its large and growing list of newspapers and magazines all of which are in exchange for the bulletins and reports of the Station.

The list comprises many of the leading agricultural publications of the day. These are preserved on file, and accessible to all interested in them. Sample copies may be obtained by mailing a request for such to the publishers.

Orange Judd Farmer, Chicago, Ill.
Elgin Dairy Report, Elgin, Ill.
National Dairyman, Kansas City, Mo.
Southern Cultivator, Atlanta, Ga.
Farm and Home, Springfield, Ill.
American Horticulturist, Topeka, Kan.
Farm and Dairy, Ames, Iowa.
North West Magazine, St. Paul, Minn.
American Meteorological Journal, Boston, Mass.
Farmers' Guide, Huntington Ind.
South West Farm and Orchard, Las Cruces, N. M.
Cultivator, Omaha, Neb.
American Fertilizer, Philadelphia, Penna.
National Nurseryman; Rochester, N. Y.
Farmers Magazine, Springfield, Ill.
North West Farmer, St. Paul, Minn.

North West Agriculturist, Minneapolis, Minn.
Farm, Stock and Home, Minneapolis, Minn.
Breeders Gazette, Chicago, Ill.
Irrigation Age, Chicago, Ill.
American Agriculturist, New York City.
Gardening, Chicago, Ill.
American Florist, Chicago, Ill.
Hoard's Dairyman, Ft. Atkinson, Wis.
Minnesota Horticulturist, Minneapolis, Minn.
Practical Nurseryman, Huntsville, Ala.
Field and Farm, Denver, Col.
American Farmer, Springfield, Ill.
Farmers' Voice, Chicago, Ill.
Clover Leaf, South Bend, Ind.
Sugar Beet, Philadelphia, Penna.
Omaha Index, Omaha, Neb.
Green's Fruit Grower, Rochester, N. Y.
Grange Visitor, Lansing, Mich.
Weekly Sun, Baltimore, Md.
Wisconsin Agriculturist, Racine, Wis.
Riverside, Red Wing, Minn.
Republican, Lake City, Minn.
Dairy World, Chicago, Ill.
Dorset Quarterly, Washington, Pa.
Poultry Monthly, Albany, N. Y.
Farmers' Call, Quincy, Ill.
Mirror and Farmer, Manchester, N. H.
Farmer and Breeder, Springfield, Ill.
Independent, Helena, Mont.
Sentinel, Boulder, Mont.
Avant Courier, Bozeman, Mont.
New Issue, Bozeman, Mont.
Chronicle, Bozeman, Mont.
Pioneer, Big Timber, Mont.
Times, Billings, Mont.
Gazette, Billings, Mont.
Inter Mountain, Butte, Mont.
Montanian, Choteau, Mont.

Silver State, Deer Lodge, Mont.
New Northwest, Deer Lodge, Mont.
Silverite, Missoula, Mont.
Inter Lake, Kalispell, Mont.
Graphic, Kalispell, Mont.
Tribune, Dillon, Mont.
Examiner, Dillon, Mont.
Western News, Hamilton, Mont.
Leader, Great Falls, Mont.
Tribune, Great Falls, Mont.
Democrat, Lewistown, Mont.
Stockgrowers Journal, Miles City, Mont.
Yellowstone Journal, Miles City, Mont.
Missoulian, Missoula, Mont.
Herald, Neihart, Mont.
Mail, Phillipsburg, Mont.
Red Lodge Picket, Red Lodge, Mont.
North West Tribune, Stevensville, Mont.
Madisonian, Virginia City, Mont.
Advertiser, Grantsdale, Mont.
Stockman and Farmer, Helena, Mont.
Times, Hamilton, Mont.
Bitter Root Bugle, Hamilton, Mont.
Rocky Mountain Husbandman, White Sulphur Springs.
Montana Mining Area, Helena, Mont.
The Rockies, Dillon, Mont.

ACKNOWLEDGMENT OF DONATIONS.

This Station makes suitable acknowledgment for the donation of the following machinery. All first class of their kind:

One Wood's Self Binder, Wood's Harvester Co., St. Paul.
One Acme Harrow, Duane H. Nash, Millington, N. J.
One Osborne Spring Tooth Harrow, D. M. Osborn & Co., Chicago.
One Babcock Butter Test, Cornish, Curtis & Green, Ft. Atkinson, Wis.
One Keystone Dehorner, A. C. Brosius, Cochranville, Pa.

Two Plant Transplanters, Rickenbacker & Baldridge, Columbus, Ohio.

One Aspinwall Potato Planter, Aspinwall Manufacturing Co., Jackson, Mich.

One Studebaker Road Cart, Studebaker Manufacturing Co., South Bend, Ind.

One McCormick Mower, McCormick Manufacturing Company, Chicago, Ill.

One Shuart Land Grader, D. M. Shuart, Oberlin, Ohio.

One Oliver Chilled Plow, South Bend, Indiana.

The following firms made substantial reductions from regular prices, for the following machinery:

Fairbanks, Morse & Co., St. Paul, Minn., platform hay and grain scales, warehouse and counter scales.

A. W. Miles & Co., Livingston, Montana, one Clark Cutaway harrow.

Johnson, Field & Co., Racine, Wis., one fan mill and one land roller.

S. L. Allen & Co., Philadelphia, one cultivator; one seeder, one Planet, Jr. garden hoe.

G. L. Pounder, Ft. Atkinson; Wis., one field harrow.

Hoover & Prout, Avery, O., one potato digger.

BULLETINS.

Four bulletins, regular series, and two bulletins for the Press, have been issued for the year ending June 30, 1894, with titles as follows,

Bulletin Number One, "Organization and Announcements," 16 pp.., by the Director.

Bulletin Number Two, "Smut of Wheat, Oats and Barley," 16 pp., by Professor Foster.

Bulletin Number Three, "Pig Feeding," 32 pp., by Professor Foster.

Bulletin Number Four, "Glanders," 64 pp., by Dr. Williams.

Press Bulletin Number One, "Smut in Wheat and Oats," 3 pp., by Professor Foster.

Press Bulletin Number Two, "Summer Fallow," 1 p., by Professor Foster.

The mailing list, to which all bulletins, "regular series," is sent, contains about 3900 names. This list is being constantly increased by mail requests for bulletins. Bulletins No.'s One, Two and Three were issued in editions of 5,000 each, Bulletin Number Four, 6,000.

The Press Bulletins are mailed to the newspapers within the state, and are very generally published by them. In addition, 3,000 copies of Press Bulletin, Number One were printed, and are being distributed to grain growers through the millers of the state.

A copy of bulletins, "regular series" and press bulletins, also the reports of the Agriculturist, the Chemist, and the Veterinarian, accompany, and constitute a part of this report.

Respectfully submitted,

S. M. EMERY, Director.

REPORT OF THE
AGRICULTURIST AND BOTANIST.

AGRICULTURE AND BOTANY.

TO THE DIRECTOR:

SIR: The work of this department up to the beginning of Spring operations on the farm, was, of necessity, mainly of a preliminary nature and of course, gave no results to embody in a report.

During the Spring, field experiments were begun in the following lines and are now in progress, but a citation of results must be deferred until another year.

In the comparative variety tests there are one hundred and eight varieties of spring wheat, forty-nine of oats, twenty-eight of barley, three of spring rye, three of buckwheat, five of corn, three of millet, five of peas, twelve of other forage plants and twenty-six of potatoes.

Preparation of the seed bed, methods of seeding and cultivation were made a part of the work.

The results of these experiments will not only give valuable data in comparative yields and qualities of varieties, but also in manner of seeding and the benefits of cultivation.

For the small grain tests, a few varieties of each kind were furnished, through the kindness of Professors Chilcott and Zavitz, by the Stations of South Dakota, and Guelph, Ontario, but we are indebted to Professor Shepperd of the North Dakota Station for the main part of the collection.

Experiments were also made in the treatment of seed wheat and oats for the prevention of smut in the crop, in the treatment of seed potatoes for the prevention of scab and in methods of destroying the potato bug.

Two bulletins were issued by the department during the year. The first, on smuts of wheat, oats and barley, discusses the extent of damage, cause and nature of the disease, and details fully the most approved methods of treating the seed to secure a crop free from smut.

The second bulletin, on pig feeding, is preliminary to the feeding experiments to be undertaken by the station. It discusses briefly the general principles of feeding and explains the methods of making food analyses. It contains tables of the average composition of nearly all American feeding stuffs and of the German feeding standards with explanations of both and directions for their use in compounding rations. It also contains a summary of the results of pig feeding experiments at other stations that are likely to be of most value to the Montana farmers.

Respectfully submitted,
LUTHER FOSTER, Prof. of Agr. and Botany.

CHEMICAL DEPARTMENT.

REPORT OF THE CHEMIST.

To THE DIRECTOR:

SIR: Below is a statement of work done to date. I arrived at my post about the middle of September last and set about arranging a laboratory for analytical work. It was nearly the end of the year before the apparatus arrived from the east, and, with what time was required to place apparatus in position, making up standard and other solutions, most of the first half year passed without much actual analytical work being accomplished.

Samples of water from the city water supply, being also that used in this laboratory, and a sample of water from Whitehall, were the first materials analyzed.

A series of samples of water from the tailings dams of silver mills, and from irrigating ditches receiving water containing some of the same, have been analyzed, for the purpose of obtaining data for an investigation of the effects of such waters upon vegetation. We have now the composition of about two dozen such waters. In a number of valleys of the state the water used for irrigation contains considerable of the soluble matter resulting from the treatment of silver ores by the chloridizing pan amalgamation process, and there have been numerous complaints and many law suits, consequent upon a belief among the farmers that such waters are injurious to stock and vegetation.

Our investigation, it is hoped, will prove the justice or the falsity of such opinions.

An effort made in the early spring to improve the character of milch cows by drawing attention to the varying grades of milk given by different cows in the same herd, has resulted in arousing a considerable amount of interest on the part of the farmers, and a large number of samples of milk have been analyzed by us to aid them in their efforts to discover the relative merits of their cows.

Twelve samples of clays, marls, soils and limestones have been analyzed.

A number of horses in transit over the Northern Pacific railway died while passing through the state and it is believed that some food given them at Missoula was the cause of the trouble. A careful investigation, looking to the real cause of the trouble ended in negative results as far as the discovery of any poisons is concerned.

Among other miscellaneous analyses may be mentioned four samples of wheat, one sample of hay, nine samples of flour from Montana wheat. The last mentioned work gave a very flattering return, and has shown us that our cereals can easily hold their place in quality as they do in yield per acre.

Very truly yours,
F. W. TRAPHAGEN, Chemist.

REPORT OF THE VETERINARIAN.

VETERINARY SCIENCE.

To the Director:

Sir: I beg to report that in the department of Veterinary Science little has been accomplished up to the present date beyond preliminary work.

Until the station is equipped with suitable buildings and conveniences for experiments upon animals, my work is necessarily limited almost wholly to field investigations, and having arrived at the Station on Oct. 24 of last year, after inclement weather had begun, outdoor work, in so far as reliable investigations were concerned, was practically impossible until the beginning of May.

My time was well occupied also from January to March inclusive, in college class work.

Sufficient instruments and apparatus for effective field work have been secured and a first-class microscope and accessories have been ordered and are now en route from New York, making an equipment sufficient for the work, except some minor material, until it is known what the needs of this locality will prove.

Field work, such as must be done, for the present acquaintance and association with stock owners, becomes of the highest importance and I have taken every opportunity practicable to become as thoroughly acquainted with these as circumstances would permit. The "Farmers' Institutes" attended at Great Falls, Townsend, Missoula, Hamilton, Bozeman, and other points, in addition to those held during

August and September in the Gallatin, Madison and Jefferson valleys, did much to lay the foundation for a good acquaintance with the class of persons upon whose co-operation the success of my department must very largely rest.

I have attended also during December, 1893, the State Teachers' Association at Butte, and in April the Stock Growers' Association at Miles City, both of which did much to extend my acquaintance.

I have contributed, besides some minor articles, one two-column paper on "Spaying" to the Miles City Stock Journal, which has been commented upon by some of the leading stock papers of the State.

Several contagious or epizootic diseases of domestic animals have been brought to my attention and some interesting facts learned although not sufficient in themselves to lead to any valuable conclusions.

Early after my arrival my attention was called to two animals suffering from the so called "Joke easy" or "Kidney disease" of horses, one of which was prescribed for as nearly as possible as indicated by the symptoms. The other died without any attempt on my part at treatment and a post mortem examination was held which revealed no diseased changes to the naked eye.

Later a bad case of the same disease was seen at Three Forks and still more recently a well marked case in this city, the latter making a prompt and very satisfactory recovery under treatment.

I was asked in April to investigate a peculiar disease among pigs belonging to Mr. T. D. Tice of Logan. The animals showed the symptoms of trichinosis or pork worm disease, but a careful microscopic examination of the flesh of the affected pig kindly sent me by Mr. Tice failed to show any trichina, the pigs kept at home recovered and no satisfactory conclusion was reached as to the cause of the disease.

My attention was called last November to glanders among horses and I visited during last year the farms of Mr. Titus and Moses Decker, some ten miles north of Bozeman and examined five glandered horses, all of which were killed.

Recently arrangements have been made with the Board of Stock Commissioners by which I have been regularly commissioned as a Deputy State Veterinary Surgeon for the entire state. This arrangement affords a good opportunity for seeing much of the diseases of live stock, while so long as my work partakes of a sanitary or police character it costs the station nothing, and more outbreaks of diseases are brought to my notice than would otherwise be done.

So far my work has been mainly with glanders, and I have examined and condemned for glanders, two horses in the city of Bozeman, six in the Gallatin valley, ten in the Madison valley, eight on the divide between the Gallatin and Madison valleys, two at Big Timber, one at Rapids and six near Billings, or a total of thirty-five cases, nearly, if not all, of which have been destroyed.

These cases have furnished me with considerable material in the way of observations and some excellent specimens, which I have made use of in a bulletin upon this affection.

Through the courtesy of Mr. C. S. Hopping, of Logan, I was permitted to try the effect of the poisonous product of glanders known as mallein, on three glandered and two apparently sound horses, and I have the promise of further opportunity in the same line with several farmers near this city.

These have been fully reported in the Glanders bulletin.

In my work and association with live stock owners I have been treated with uniform courtesy and every opportunity has been offered for investigations, and as my acquaintance extends there can be no doubt but that a great abundance of material for very interesting investigations will be offered which will lead to conclusions of value to the stock interests of the state.

I desire to take up such diseases in the future as may offer the best and most convenient material for study, there being so many diseases peculiar to this region, the exact nature of which is unknown, that there is little choice between them.

Respectfully submitted,
W. L. WILLIAMS, V. S.

630.679
M9eb

UNIV. OF
JAN

5-3
76

BULLETIN NO. 6.

MONTANA
AGRICULTURAL
EXPERIMENT STATION

MEASUREMENT OF WATER.

BOZEMAN, MONTANA, JUNE, 1895.

Compliments of
A. M. Ryon

The Avant Courier,
Book and Job Printers,
Bozeman, Mont., '95.

MONTANA AGRICULTURAL

EXPERIMENT STATION.

EXECUTIVE BOARD.

LESTER S. WILLSON, President	Bozeman.
PETER KOCH, Secretary and Treasurer	Bozeman.
GEORGE KINKEL, JR., Vice-President	Manhattan.
WALTER COOPER	Bozeman.
NELSON STORY	Bozeman.

EXPERIMENT STATION STAFF.

S. M. EMERY	Director and Horticulturist.
LUTHER FOSTER, M. S. A.	Agriculturist and Botanist.
F. W. TRAPHAGEN, Ph. D., F. C. S.	Chemist.
W. L. WILLIAMS, V. S.	Veterinarian.
A. M. RYON	Irrigation Engineer.

Post Office Address and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

MONTANA EXPERIMENT STATION,
Bozeman, Montana.

NOTICE: The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Experiment Station.

Bulletin No. 6. - - - **June, 1895.**

MEASUREMENT OF WATER.

BY A. M. RYON, E. M.

It is only within comparatively few years that public attention in the U. S. has been directed very generally to the importance of irrigation. One reason for this is that the business of mining has occupied the attention of westerners to the exclusion, in a great measure, of almost every other industry. The depression in the price of silver, resulting in the closing of almost every silver mine in the country, and consequently forcing a large portion of the populace to seek work, has naturally called attention to the fact that the so called arid states along the Rocky mountains have other resources, more lasting and of fully as great importance to the country as its mines.

The eastern states with their great armies of unemployed men are interested in the fact that water and labor combined will change a desert into a fertile country. Here is an opportunity to convert an idle, restless and consequently dangerous element into industrious and contented communities.

The great commercial centers should be interested in any move which increases the general prosperity of the country at large; for their prosperity depends upon the resources of the contributing districts.

FERTILIZATION OF IRRIGATION WATER.

The impression, formerly prevalent, that irrigation is a drawback rendered necessary by reason of a deficient rain fall, has now largely given way, in the light of experience, to a realization of the great advantages which accrue in the regularity and certainty of crops, as well as in the fertilization of the soils. The value of irrigation water as a fertilizer has been demonstrated not only in this country but in the older communities. The lands in Upper Egypt irrigated by the Nile are as productive to-day as they were hundreds of years ago and the only fertilizer used was the silt deposited by the river water. The Nile water carries large quantities of organic matter together with salts of potash and phosphoric acid, all of which serve a useful purpose in the production of crops. In Lower Egypt where the improved system, which does not give the slime from the water time to settle sufficiently, has been used during the past fifty years the soil has already commenced to deteriorate.*

In the Madras Presidency, India, Mr. J. H. Latham, C. E., states that water from rivers are considered to give 25% more crop per acre than water taken from either wells or tanks. Mr. Geo. Gordon, C. E., makes the same statement regarding waters from other parts of India. According to Mr. P. J. Flinn, C. E., the district of Tanjore, India, is believed to produce as large crops now as it did 2,000 years ago and this with no other fertilization than that which comes from the irrigation water.

The mineral constituents carried in solution also, as might be supposed, have an effect upon the crops irrigated; while some of these compounds may be injurious others are certainly beneficial, especially those coming through limestone districts and carrying sulphate of lime (gypsum).

Thus the Kistnah river, India, which passes through a limestone country, has a delta which was found to produce crops 50 per cent larger than the delta of the Godavery, which passes through a granite country. At Riverside, Cal., it is estimated that 20,000 lbs. of oranges require a total of 42 lbs. of potash, while the irrigation waters used supply 35 lbs.

---

* Mr. W. L. Willcocks, Irrigation in Egypt.

Absolutely barren ground may be made productive by the deposition of silt from water used for irrigation. In France gravel beds have been converted into fertile fields by this means.

●

DUTY OF WATER.

The amount of irrigation which a given amount of water will accomplish determines the duty of water.

We express the duty of water by stating the total depth of water applied to a given tract during the season; or by stating the number of acres which a constant flow of a given quantity of water will irrigate. A flow of one cubic foot (7.48 gallons) of water per second will very nearly cover two acres of ground to a depth of one foot in a day of 24 hours. As ordinarily expressed we would say that two acres of ground covered with water one foot in depth would require a second-foot of water flowing 24 hours, or one half a second-foot flowing 48 hours.

It is a matter of considerable importance to know just how much water a given tract of land will require, and statistics on this subject are eagerly sought for by irrigation canal projectors, as well as by the consumers, who pay so much per year for a given quantity of water.

We find a great variation in the reported duties from different sections, ranging from 2,000 acres for a flow of one cubic foot a second (about 40 Montana statutory inches) to a depth of 200 feet per year.

In the United States the usual answer to an inquiry concerning the amount of water used for irrigation per acre is that one inch is required.

Notwithstanding these reports it is well understood that the amount of water actually needed varies with many conditions, including the nature of the crop, method of irrigation, character of the soil and sub-soil, amount of rainfall, slope of the ground, climate, skill of the irrigator and the number of previous irrigations.

As all the irrigating is not done at precisely the same time it is important to know how much water will be required for a given district during the irrigating season. It is quite possible that the rate of flow of a stream may be insufficient providing all irrigators drawing water from it attempt to irrigate at the same time and yet be ample where rotation is practiced. Our system of prior rights regulates this to a certain extent but not altogether satisfactorily. Ignorance or carelessness on the part of prior holders may result in working gross injustice by causing the waste of water which would otherwise be used by subsequent appropriators.

The rate of flow (expressed in inches or otherwise) does not afford sufficient data for us to compute the duty of water. We should know the length and frequency of the periods during which this flow is maintained.

No one would think of irrigating an acre with one inch of water, for it could not be spread over the ground; fifty inches would be ample yet it would be used only about 1/50 of the time required for fifty acres. In many cases fifty inches would be sufficient for 100 acres, yet it would have to be used for a longer period; by this time, in some localities, it may be necessary to commence another irrigation. This would determine ½ an inch per acre during the irrigating season as the flow necessary in that portion of the country.

Prof. L. G. Carpenter, of Fort Collins, Colo., gives the following results of experiments carried on under his supervision. On the farm of Hon. J. S. McClelland, the slope of the land averaged about fifty feet per mile. The soil consisted of sand and clay with more or less humus. Various crops required during the season the following depths of water, expressed in feet.

Alfalfa, plat E, 1.67; Alfalfa, plat AB, 1.85; Clover, 2.28; Wheat, plat G, 2.20; Wheat, plat C, 1.72: Oats, 2.53.

The depths given above included the rainfall which amounted to about 0.83 of a foot.

On the wheat farm of Mr. W. Campbell, where the soil consisted of sandy loam, water to the depth of 1.1 ft. was applied in two irrigations; three inches of rain fell during this period.

In 1891 native hay on the field of W. M. Post required about 2.9 feet depth of water, one crop being cut. In 1892, a depth of 2.4 feet was required.

THE MEASUREMENT OF WATER FOR IRRIGATION PURPOSES.

In the arid region there are approximately 5600 square miles of irrigated area, or about one-half of one per cent of the total area of the lands within the states and territories of the United States where irrigation is commonly practiced.* Of the remaining land, amounting to about 1,400,000 square miles, 1,062,000 square miles, approximately, is classed as desert and pasture land. The proportion of this enormous tract which can be irrigated will depend to a great extent upon the thoroughness with which we utilize our water supply. Careless measurement frequently results in waste and injustice.

Lands which might be valuable if irrigated are frequently rendered of little or no value by reason of the extravagant use of water by those holding prior rights. Accurate and reliable systems of measurement will do much toward remedying this evil. Recording devices would give us data concerning the duty of water, which would be of inestimable value in aiding us to equitably apportion our water and would serve as checks upon waste by extravagance or carelessness.

The method of measuring water in Montana authorized by law is given as follows:

EXTRACT FROM COMPILED STATUTES OF MONTANA.

"Sec. 1262. The measurement of water appropriated under this chapter shall be conducted in the following manner: A box or flume shall be constructed with a head-gate placed so as to leave an opening of six inches between the bottom of the box or flume and the lower edge of the head-gate, with a slide to enter at one side of and of sufficient width to close the opening left by the head-gate, by means of which the dimensions of the opening are to be adjusted. The box or flume shall be placed level, and so arranged that the stream in passing through the aperture is not obstructed by backwater, or an eddy below the gate; but before entering the opening to be measured the stream shall be brought to an eddy, and shall stand three inches on the head-gate and above the opening. The number of square inches contained in the opening shall be the measure of inches of water."

---

* Report on Agriculture by Irrigation, F. H. Newell.

The Montana Society of Civil Engineers, recognizing the ambiguity and imperfection of this statute, endeavored to have it repealed and another law substituted which would establish a definite quantity of water flowing past a point in a given time as the standard. They proposed that a cubic foot (7.48 gallons) of water flowing in one second of time be taken as the standard, and that where water rights had been decreed by the courts 40 statutory inches should be considered equivalent to one cubic foot per second; that is a stream flowing 40 statutory inches would fill a vessel of one cubic foot capacity in one second of time.

The objections urged by the engineers against the present statute are:

1. It is ambiguous and no accepted definition of the word eddy will apply and make sense.

2. The velocity of the approaching water may be varied. If the head or height of the surface of the water be measured directly over the opening and a box or flume be used there must be a certain velocity of approach, even if one end of the box or flume tap a lake. This velocity may be altered by altering the width of the box or flume in comparison with the width of the opening through which the water flows.

For example, if we have an opening through which 100 statutory inches are flowing (6″×16⅔″) with a box or flume of the same width, a very usual condition, we would have the area of the approaching stream (6″ + 3″) × 16⅔″=150 square inches; 100 statutory inches are equal to about 2½ cubic feet per second, so that the water would approach the opening with a velocity of about 2.4 feet per second. The theoretical value of the extra head due to this velocity would be something over one inch, making the actual head over the center of the opening something over 7 in. instead of 6 in. as apparently contemplated by the law. This would increase the flow about 6.4 per cent. This amount may be increased by bringing the water to the box with an initial velocity greater than 2.4 feet per second, or may be decreased by widening the box.

3. All measurements of head taken directly over the opening must necessarily be approximations, this may be a matter of little or no importance for small openings, but as the difficulty in securing accurate measurements increases with the size of the opening there eventually comes a limit beyond which it is practically impossible to measure water by the statutory inch box with any pretention to accuracy. On an opening of 42″ wide the surface of the water over the middle of the opening is depressed about ½ of an inch below the surface at the end of the opening.

The proper place to measure the head or height of the surface of the water above the opening is several feet up stream from the opening, but the statute does not provide for this.

4. The statute does not provide for the measurement of large bodies of water. A stream carrying 6,000 inches of water would under the statute require a box 1,000 inches or about 84 feet wide.

5. The Montana statutory inch does not represent any particular quantity of water, but a quantity increasing with the number of inches flowing. For instance, where the flow is 36 statutory inches, one inch is equivalent to about 15108 gallons; but where 180 statutory inches are flowing, one inch is equivalent to about 15964 gallons.

So long as we have plenty of water and there is no occasion for economizing it must be confessed that a miner's inch box or a statutory inch box gives satisfactory results. The fact that it was so generally adopted throughout the west during the early days and has survived in so many communities to the present time are strong recommendations that it has filled the needs of the past and if the west of the future is to be identical with the west of the past it would seem hardly worth while to attempt to improve our method of water measurement.

It is generally conceded that the strong point of all measurements on the "inch" basis lies in the fact that no formulas or tables are necessary and this was formerly a matter of paramount importance in the west. To-day any body can obtain weir tables free of cost from our Experiment Station and determine with a considerable degree of accuracy and no more expense than before, the actual amount of water flowing. Further, if desired, this amount can be, at a slight expense, permanently recorded by the use of an automatic registering device. It is not easy to estimate the number of quarrels between neighbors taking water from the same stream or canal, which would be effectually prevented by the use of these simple little witnesses.

WEIR MEASUREMENTS.

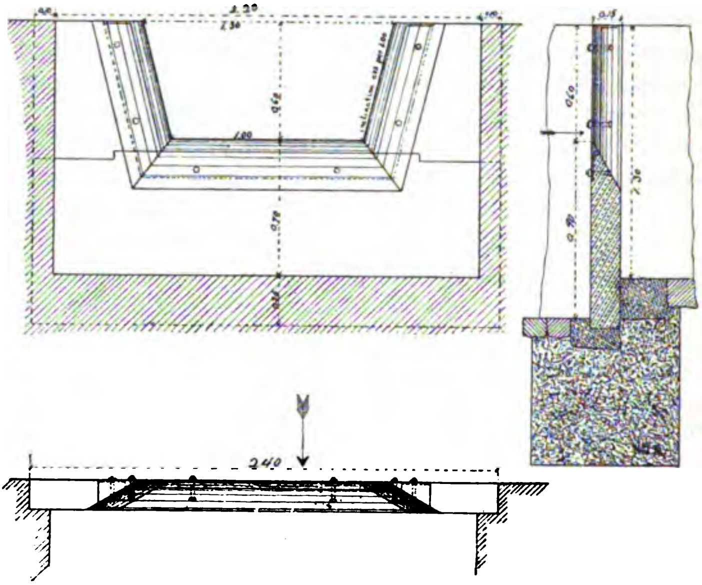
No device for measuring flowing water has been more thoroughly tested and experimented with than the weir, with the result that notwithstanding the simplicity of its construction we may, by taking proper precautions, determine the amount of water flowing over it within one per cent.

An idea of a measuring weir may be obtained from the insert giving views of the Cippoletti weir. The opening in this case is trapezoidal in shape, although a rectangular shaped opening has been perhaps more frequently used. Where very accurate measurements are desired, the edges of the opening are made of comparatively thin metal. The amount of water passing through the opening is determined by considering the length of the weir and the height of the surface of the water over the horizontal edge or crest of the weir as it is usually called.

In flowing through the opening the stream is contracted by reason of the water passing around the edges, so that the area of its cross section is smaller than the area of the opening. With a given opening if we widen and deepen the box to certain limits we increase the contraction; beyond these limits no further contraction is observed. The contraction is then said to be complete, otherwise it is said to be partial. Where the bottom and sides of the box coincide with the edges of the weir the contraction is said to be suppressed. The suppression may also be accomplished in other ways. For convenience a weir with complete or nearly complete contraction is usually used.

The extensive experiments made at Lowell, by Mr. J. B. Francis, with every facility for obtaining accurate results, have demonstrated that for complete end contractions where the depths over the crest of the weir are from three to twenty-four inches and the length is not less than three times the depth, the effective length of the weir is reduced an amount equal to 0.1 of the depth of water over the crest for each end contraction. Where there are two end contractions the effective length is reduced twice this amount. Francis' formula for the discharge of water through rectangular weirs with two end and a bottom contraction is $Q=3.33\ (l-0.2\ h)\ h^{3/2}$ in which Q=the discharge in cubic feet per second; l=the length of the weir in feet; h=the head or height of the surface of the water over the crest, expressed in feet and measured at a point several feet up stream from the crest.

The Italian government in making a concession of water for the Villoresi Canala, a canal irrigating about 125,000 acres, required the company to propose an accurate measuring device or module which should be based on the theory of the weir. The company employed Cesare Cippoletti, an able engineer, to take charge of the work. Using Francis' formula as a basis, Cippoletti attempted to slope the sides of the opening so as to give an increased discharge sufficient to compensate for the loss due to contraction. The slope he determined upon was 1 in 4.



THE CIPPOLETTI MEASURING WEIR.

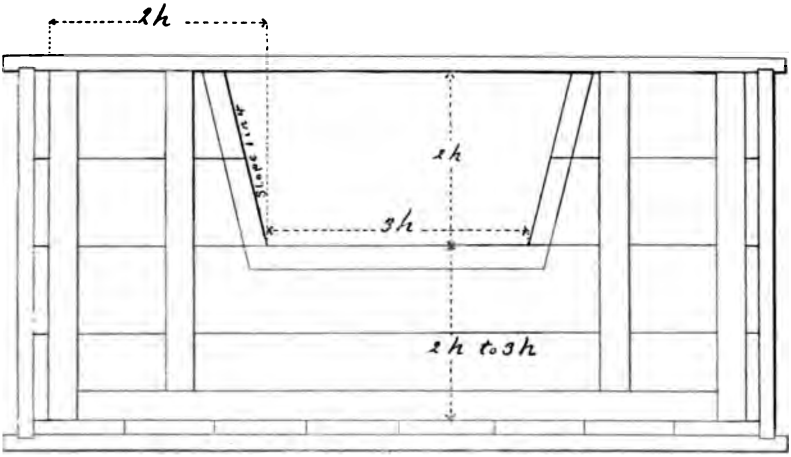
Messrs. Flinn and Dyer of the Worcester Polytechnic school, under the direction of Mr. Clemens Herschel, a prominent hydraulic engineer of New York City, undertook a series of careful experiments at Holyoke, Mass., to test the accuracy of the Cippoletti weir. Their experiments showed that an error of but slightly over ½ per cent might be looked for, providing proper precautions are taken.* The use of this weir simplifies the formula used by Francis so that the discharge may be expressed as follows: $Q=3.3\frac{2}{3}\ l\ h^{3/2}$ in which Q=the discharge in cubic feet per second; l=the length of the crest of the weir in feet; h=the head expressed in feet and measured several feet up stream from the crest.

---

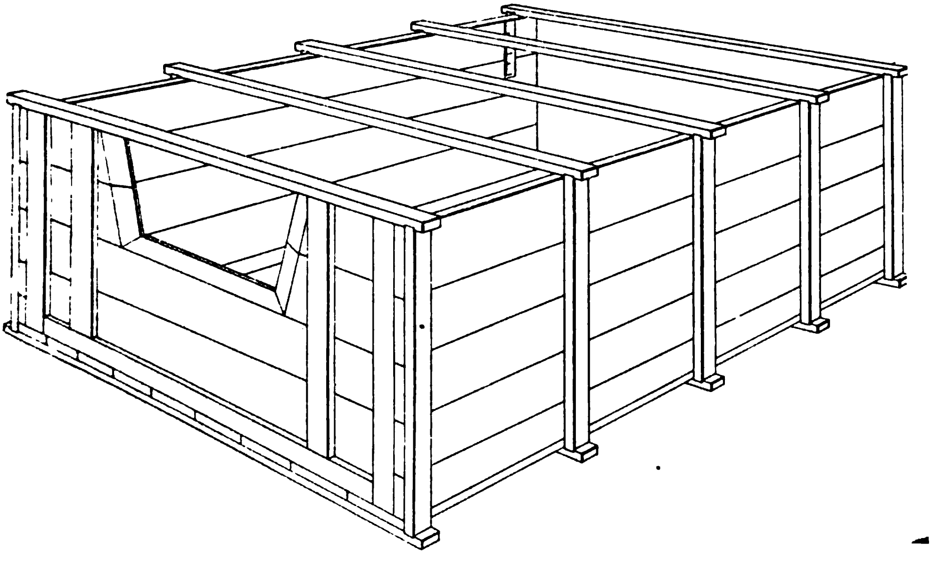
* Trans. Am. Soc. Civil Engineers, July, '94.

THE CIPPOLETTI WEIR
FOR THE
MEASUREMENT OF WATER.

h = the height of the surface of the water over the crest.



ELEVATION.



PERSPECTIVE

ADVANTAGES OF THE WEIR.

The principal advantages of the weir are:

1. Cheapness.
2. Ease of construction.
3. Accuracy.
4. It gives the amount of water flowing in terms understood the world over.
5. It is not necessary to maintain a constant head in order to determine the amount of water passing.
6. A small loss of head, (smaller than the Montana Statutory inch).

The only drawback which can be urged against its use is that it requires those who cannot solve an algebraic formula to use a table. A very slight disadvantage to place against so many advantages.

PRECAUTIONS NECESSARY FOR ACCURATE RESULTS.

In order to obtain reliable results in measuring water by any method certain precautions are necessary. Where water is measured with a weir the following conditions ought to be observed:

1. The approaching channel should be straight and of uniform cross section, in order to avoid eddies and cross currents, for a distance of not less than fifty feet before reaching the weir.

2. The formulas assume that the contraction of the escaping jet of water is complete. In order to obtain complete contraction, the weir opening should lie in a plane perpendicular to the direction of the stream; the edges should be sharp on the up stream side and cut away on the down stream side so as to reduce the thickness of the edge in contact with the water. To insure perfect contraction the distance from the crest of the weir to the bottom of the channel should be three times the depth of the water flowing over the crest; the crest should also be a distance from either side of the channel equal to twice the depth of water flowing over it. The length of the weir should be three times the depth of the water over the crest and the depth of water

on the crest should not be less than three inches.

3. In order that the velocity of the approaching water may not be excessive, the channel should have an area of cross section of at least seven times the area of the weir opening.

4. Air should be allowed to circulate freely around the escaping body of water where it leaves the weir. The flow is not impeded by raising the surface of the water in the lower channel, providing it is not raised so far as to prevent free circulation of air entirely around the water issuing from the weir opening.

5. The height of the surface of the water over the weir should be measured at a point several feet up stream from the weir, so as to avoid the depression which occurs as the water approaches the opening.

The effect of decreasing the distance of the sides of the weir from the crest is to increase the discharge. Ordinarily if this distance is decreased to a distance equal to the depth of water over the crest, the increased discharge amounts to about 1 per cent. A further decrease in the distance increases the discharge more rapidly. When the bottom of the channel is below the crest a distance equal to twice the depth of water on the crest, the increase flow ordinarily amounts to about 1 per cent.

Experimenters have not agreed entirely as to the proper allowance to be made as a correction for the velocity of the approaching water. In ordinary practice if the approaching channel has an area of cross section not less than seven times the area of the weir opening, the error is not sufficient to be worthy of consideration.

Where it is desired to take the velocity of approach into account, it may be done as follows:

Let Q=the approximate amount of water flowing, found from the table by using the measured head H and expressed in feet per second; A=the area of cross section of the channel, expressed in square feet; then $\frac{Q}{A}=V$=the velocity of the approaching water expressed in cubic feet per second; let h be the head, expressed in feet, due to the velocity of approach, then: $h=1.4 (V^2 \div 64.4)$. This will give a close approximation. The value of h should be added to H and the discharge due to h+H, found from the tables. The factor 64.4 decreases slightly as the elevation and latitude increase, becoming 64.29 for an altitude of 5,000 feet in latitude 40°.

The table appended is taken from the excellent bulletin compiled by Prof. L. G. Carpenter of the Colorado Agricultural Experiment Station.

TABLE I.

Discharge Over Rectangular Weirs, With and Without Contraction.

Formula, $D=3\frac{1}{3}(1-.2 H) H^{3/2}$.

For Precautions see Page 160.

Depth, H, of Water on Crest Measured in Still Water		DISCHARGE IN CUBIC FEET PER SECOND.						
		WITH TWO COMPLETE CONTRACTIONS.						Correction to be ADDED to each of the preceding to give discharge with NO contraction.
In Inches	In Feet	1 Foot Long	1½ Feet Long	2 Feet Long	3 Feet Long	5 Feet Long	10 Feet Long	
0.3	.025	.0133	.0200	.0267	.0400	.0677	.1330	.0000
0.6	.050	.0369	.0556	.0743	.1116	.1863	.3716	.0004
0.9	.075	.0671	.1015	.1350	.2040	.3410	.6830	.0010
1.2	.1	.1033	.1560	.2087	.3132	.5240	1.0519	.0021
1.5	.125	.1438	.2175	.2912	.4385	.7332	1.4695	.0037
1.8	.15	.1879	.2847	.3816	.5753	.9627	1.9312	.0058
2.1	.175	.2355	.3575	.4795	.7235	1.2115	2.4315	.0085
2.4	.2	.2861	.4352	.5843	.8824	1.4787	2.9690	.0119
2.7	.225	.3399	.5177	.6956	1.0513	1.7627	2.5412	.0160
3.0	.25	.3959	.6012	.8126	1.2293	2.0227	4.1462	.0208
3.3	.275	.4543	.6946	.9350	1.4157	2.3771	4.7803	.0264
3.6	.3	.5149	.7888	1.0627	1.6104	2.7059	5.4442	.0328
3.9	.325	.5775	.8863	1.1952	1.8129	3.0482	6.1363	.0401
4.2	.35	.6420	.9871	1.3321	2.0223	3.1032	6.8587	.0483
4.5	.375	.7079	1.0909	1.4732	2.2335	3.7691	7.5976	.0574
4.8	.4	....	1.1974	1.6189	2.4623	4.1485	8.3615	.0675
5.1	.425	....	1.3070	1.7680	2.6926	4.5400	9.1565	.0785
5.4	.45	....	1.4189	1.9221	2.9280	4.9401	9.9775	.0906
5.7	.475	....	1.5333	2.0790	3.1708	5.3523	10.8094	.1037
6.0	.5	....	1.6500	2.2392	3.4177	5.7748	11.6672	.1178
6.3	.525	....	1.7689	2.4029	3.6709	6.2069	12.5469	.1331
6.6	.55	....	1.8890	2.5698	3.9295	6.6489	13.4474	.1196
6.9	.575	....	2.0129	2.7395	4.1928	7.0995	14.3668	.1672
7.2	.6	....	2.1378	2.9123	4.4614	7.5596	15.3052	.1859
7.5	.625	....	2.2646	3.0881	4.7351	8.0291	16.2641	.2059
7.8	.65	....	2.3929	3.2665	5.0133	8.5069	17.2409	.2271
8.1	.675	....	2.5231	3.3478	5.2960	8.9930	18.2354	.2496
8.4	.7	....	....	3.6313	5.5836	9.4832	19.2497	.2733
8.7	.725	....	....	3.8170	5.8747	9.9906	20.2796	.2984
9.0	.75	....	....	4.0052	6.1702	10.5007	21.3262	.3248
9.3	.775	....	....	4.1961	6.4704	11.0190	22.3895	.3524
9.6	.8	....	....	4.3888	6.7734	11.5444	23.4704	.3816
9.9	.825	....	....	4.5833	7.0810	12.0769	24.5659	.4121
10.2	.85	....	....	4.7806	7.3929	12.6169	25.6779	.4440
10.5	.875	....	....	4.9792	7.7075	13.1641	26.8056	.4775

Discharge Over Rectangular Weirs.—Concluded.

Depth, H, of Water on Crest Measured in Still Water		DISCHARGE IN CUBIC FEET PER SECOND.						
		WITH TWO COMPLETE CONTRACTIONS.						Correction to be ADDED to each of the preceding to give discharge with NO contraction.
In Inches	In Feet	1 Foot Long	1½ Feet Long	2 Feet Long	3 Feet Long	5 Feet Long	10 Feet Long	
10.8	.9	....	....	....	8.0257	13.7177	27.9477	.5123
11.1	.925	....	....	....	8.3509	14.2889	29.1164	.5486
11.4	.95	....	....	....	8.6731	14.8461	30.2786	.5864
11.7	.975	....	....	....	9.0012	15.4192	31.4652	.6258
12.0	1.0	....	....	....	9.3333	16.0000	32.6667	.6667
12.3	1.025	....	....	....	9.6685	16.5869	33.8829	.7091
12.6	1.05	....	....	....	10.0058	17.1789	35.1109	.7531
12.9	1.075	....	....	....	10.3471	17.7777	36.3552	.7988
13.2	1.1	....	....	....	10.6907	18.3825	37.6100	.0849
13.5	1.125	....	....	....	11.0376	18.9926	38.8801	.8949
13.8	1.150	....	....	....	11.3866	19.6080	40.1625	.9455
14.1	1.175	....	....	....	11.7388	20.2298	41.4573	.9977
14.4	1.2	....	....	....	12.0935	20.8569	42.7664	1.0516
14.7	1.225	....	....	....	12.4507	21.4893	44.0866	1.1073
15.0	1.25	....	....	....	12.8109	22.1279	45.4204	1.1646
15.3	1.275	....	....	....	13.1733	22.7713	46.7653	1.2237
15.6	1.3	....	....	....	13.5375	23.4189	48.1221	1.2846
15.9	1.325	....	....	....	13.9067	24.0727	49.4927	1.3473
16.2	1.35	....	....	....	14.2740	24.7308	50.8733	1.4117
16.5	1.375	....	....	....	14.6450	25.3946	52.2671	1.4780
16.8	1.4	....	....	....	....	26.0625	53.6710	1.5460
17.1	1.425	....	....	....	....	26.7355	55.0870	1.6160
17.4	1.45	....	....	....	....	27.4127	56.5182	1.6878
17.7	1.475	....	....	....	....	28.0950	57.9515	1.7615
18.0	1.5	....	....	....	....	28.7814	59.3999	1.8371
18.3	1.525	....	....	....	....	29.4729	60.8604	1.9146
18.6	1.55	....	....	....	....	30.1680	62.3300	1.9940
18.9	1.575	....	....	....	....	30.8681	63.8116	2.0754
19.2	1.6	....	....	....	....	31.5717	65.3022	2.1588
19.5	1.625	....	....	....	....	32.2809	66.8049	2.2441
19.8	1.650	....	....	....	....	32.9935	68.3175	2.3314
20.1	1.675	....	....	....	....	33.7093	69.8398	2.4207
20.4	1.7	....	....	....	....	34.4299	71.3719	2.5121
20.7	1.725	....	....	....	....	35.1546	72.9146	2.6054
21.0	1.750	....	....	....	....	35.8827	74.4672	2.7009
21.3	1.775	....	....	....	....	36.6151	76.0286	2.7984
21.6	1.8	....	....	....	....	37.3510	77.6002	2.8979
21.9	1.825	....	....	....	....	38.0909	79.1814	2.9996
22.2	1.85	....	....	....	....	38.8346	80.7726	3.1034
22.5	1.875	....	....	....	....	39.5812	82.3717	3.2093
22.8	1.9	....	....	....	....	40.3321	83.9816	3.3173
23.1	1.925	....	....	....	....	41.0860	85.6005	3.4276
23.4	1.95	....	....	....	....	41.8436	87.2271	3.5399
23.7	1.975	....	....	....	....	42.6045	88.8635	3.6545
24.	2.0	....	....	....	....	43.3695	90.5061	3.771
27.	2.25	....	....	....	....	....	107.44	5.06
30.	2.50	....	....	....	....	....	125.17	6.59
36.	3.00	....	....	....	....	....	162.81	10.39

TABLE II.

Discharge over Cippoletti's Trapezoidal Weir of Various Lengths and with Various Depths, and Over Rectangular Weirs Without Side Contraction.

Formula, $D=3.3\frac{2}{3} L H^{3/2}$.

For Precautions see Page 160.

Depth of Water on Crest.		DISCHARGE IN CUBIC FEET PER SECOND.						
In Inches.	In Feet.	1 Foot Long.	1½ Feet Long.	2 Feet Long.	3 Feet Long.	4 Feet Long.	5 Feet Long.	10 Feet Long.
.3	.025	.0135	.0202	.0269	.0404	.0539	.0673	.1347
.6	.05	.0367	.0566	.0754	.1131	.1508	.1885	.3771
.9	.075	.0690	.1035	.1380	.2071	.2761	.3451	.6902
1.2	.10	.1064	.1596	.2128	.3192	.4256	.5319	1.0639
1.5	.125	.1488	.2232	.2976	.4464	.5952	.7440	1.4881
1.8	.15	.1956	.2934	.3912	.5868	.7824	.9780	1.9560
2.1	.175	.2464	.3697	.4929	.7393	.9858	1.2322	2.4644
2.4	.20	.3010	.4515	.6020	.9029	1.2039	1.5049	3.0098
2.7	.225	.3592	.5388	.7184	1.0777	1.4369	1.7961	3.5922
3.0	.25	.4208	.6312	.8417	1.2625	1.6833	2.1041	4.2083
3.3	.275	.4855	.7282	.9709	1.4564	1.9419	2.4273	4.8547
3.6	.30	.5531	.8297	1.1063	1.6594	2.2126	2.7657	5.5314
3.9	.325	.6238	.9358	1.2477	1.8715	2.4954	3.1192	6.2384
4.2	.35	.6972	1.0459	1.3945	2.0917	2.7890	3.4862	6.9724
4.5	.375	.7730	1.1595	1.5460	2.3190	3.0920	3.8649	7.7299
4.8	.40	....	1.2777	1.7035	2.5553	3.4071	4.2588	8.5177
5.1	.425	....	1.3993	1.8658	2.7987	3.7316	4.6645	9.3290
5.4	.45	....	1.5246	2.0328	3.0492	4.0656	5.0820	10.1640
5.7	.475	....	1.6534	2.2045	3.3067	4.4089	5.5112	11.0225
6.0	.50	....	1.7854	2.3805	3.5708	4.7610	5.9512	11.9025
6.3	.525	....	1.9210	2.5614	3.8420	5.1227	6.4034	12.8068
6.6	.55	....	2.0599	2.7465	4.1198	5.4930	6.8663	13.7326
6.9	.575	....	2.2018	2.9357	4.4036	5.8715	7.3393	14.6787
7.2	.60	....	2.3472	3.1293	4.6939	6.2585	7.8231	15.6463
7.5	.625	....	2.4955	3.3274	4.9911	6.6548	8.3185	16.6370
7.8	.65	....	2.6462	3.5283	5.2924	7.0565	8 8206	17.6413
8.1	.675	....	2.8007	3.7343	5.6014	7.4686	9 3357	18.6715

Depth of Water on Crest.		DISCHARGE IN CUBIC FEET PER SECOND.					
In Inches.	In Feet.	2 Feet Long.	3 Feet Long.	4 Feet Long	5 Feet Long	7 Feet Long	10 Feet Long
8.4	.7	3.9437	5.9156	7.8874	9 8593	13.8030	19.7186
8.7	.725	4.1565	6.2347	8.2930	10.3912	14.5457	20 7824
9 0	.75	4 3733	6.5599	8.7466	10.9332	15.3065	21.8675
9.3	.775	4.5942	6.8912	9.1883	11 4854	16.0796	22.9708
9.6	.80	4.8177	7.2263	9.6354	12.0442	16 8619	24.0885
9.9	.825	5.0453	7.5679	10.0906	12.6132	17.6585	25.2264
10.2	.85	....	7.9154	10.5538	13.1923	18.4692	26.3846
10.5	.875	....	8.2669	11.0225	13.7781	19.2893	27.5562
10.8	.90	....	8.6234	11.4978	14.3723	20.1212	28.7446
11.1	.925	....	8.9850	11.9800	14.9749	20.9649	29 9499
11.4	.95	....	9.3516	12.4688	15.5860	21.8204	31.1720
11.7	.975	....	9.7233	12 9644	16.2054	22.6876	32 4019
12.0	1.00	....	10.1000	13.5667	16 8333	23.5667	33 6667
12.3	1 025	....	10.4808	13.9744	17.4679	24.4551	34.9359
12.6	1.05	....	10 8666	14.4888	18 1110	25.3554	36.2220
12.9	1.075	....	11.2575	15.0100	18.7624	26.2674	37.5249
13.2	1.10	....	11.6524	15.5365	19.4206	27.1888	38.8412
13.5	1.125	....	12.0513	16.0684	20.0855	28.1198	40.1711
13.8	1.150	....	12.4553	16 6071	20.7588	29.0624	41.5177
14.1	1.175	....	12 8644	17.1525	21.4106	30.0168	42.8812
14.4	1 2	....	13.2764	17.7019	22.1274	30.9784	44.2548
14.7	1.225	....	13.6936	18.2581	22.8226	31.9517	45 6453
15.0	1.25	....	14.1148	18 8197	23.5246	32.9344	47.0492
15.3	1.275	....	14.5410	19.3880	24.2349	33.9289	48 9699

Discharge Over Cippoletti Weirs.—Concluded.

Depth of Water on Crest.		DISCHARGE IN CUBIC FEET PER SECOND.			
In Inches.	In Feet.	4 Feet Long.	5 Feet Long.	7 Feet Long.	10 Feet. Long.
15.6	1.3	19.9603	24.9508	34.9305	49.9007
15.9	1.325	20.5894	25.6742	35.9439	51.3484
16.2	1.35	21.1238	26.4047	36.9666	52.8095
16.4	1.375	21.7123	26.1404	37.9966	54.2808
16.8	1.4	22.3075	27.8844	39.0882	55 7688
17.1	1.425	22.9082	28.6352	40.0898	57.2704
17.4	1.45	23.5128	29.3910	41.1474	58.7820
17.7	1.475	24.1242	30.1552	42.2173	60.3105
18.0	1.5	24.7396	30.9245	43.2943	61.8490
18.3	1.525	25.3604	31.7005	44.3808	63.4011
18.6	1.55	25.9866	32.4833	45.4766	64.9666
18.9	1.575	26.6182	33.2727	46.5818	66.5455
19.2	1.6	....	34.0685	47.6959	68.1370
19.5	1.625	....	34.8702	48.8183	69.7405
19.8	1.65	....	35.6782	49.9495	71.3565
20.1	1.675	....	36.4918	51.0878	72.9826
20.4	1.7	....	37.3111	52.2855	74.6222
20.7	1.725	....	38.1376	53.3926	76.2752
21 0	1.75	....	38.9691	54.5568	77.9383
21.3	1.775	....	39.8074	55.7804	79.6149
21.6	1.8	....	40.6515	56.9121	81.3030
21.9	1.825	....	41.5009	58.1018	83.0018
22.2	1.85	....	42.3577	59.3008	84.7154
22.5	1.875	....	43.2179	60.5031	86.4358
22.8	1.9	....	....	61.7211	88.1730
23.1	1.925	....	....	62.9442	89.9208
23.4	1.95	....	....	64.1720	91.6743
23.7	1.975	....	....	65.4116	93.4452
24 0	2.0	....	....	66.6560	95.2228
25.5	2.125	....	....	72.999	104.289
27 0	2.25	....	....	79.541	113.63
28.0	2.4	....	....	87.619	125.18
30.0	2.5	....	....	93.156	133.07

SOME PHYSICAL CONSTANTS USEFUL IN CONNECTION WITH THE PRECEDING TABLES.

1 cu. ft. water weighs 62.416 lbs. at 32 degrees F.

1 cu. ft. water weighs 62.424 lbs. at 39.3 degrees F.

1 cu. ft. water weighs 62.408 lbs. at 50 degrees F.

1 cu. ft. water weighs 62.300 lbs. at 70 degrees F.

1 cu. ft.=7.48052 U. S. gallons.

1 acre ft.=an acre 1 ft. deep=43,560 cu. ft.=325,851.45 gallons.

1,000,000 U. S. Gallons=133,680.6 cu. ft.=3.07 acre ft.

1,000,000 cu. ft.=22.9568 acre ft.=11.574 cu. ft. per sec. for 24 hrs.

1 cu. ft. per sec.=448.8312 gallons per minute=86,400 cu. ft. in 24 hrs. (Nearly 2 acre feet.)=2 acre ft. in 24 hrs , 12 min.=1,000,000 cu. ft. in 11.574 days=1,000,000 gals. in 1.5472 days.

1 cu. ft. per sec.=38.4 Colorado statute inches=50 California statute inches=40 Montana statute inches.

1.44 cu. ft. per sec. covers 80 acres 6 inches deep in 14 days.

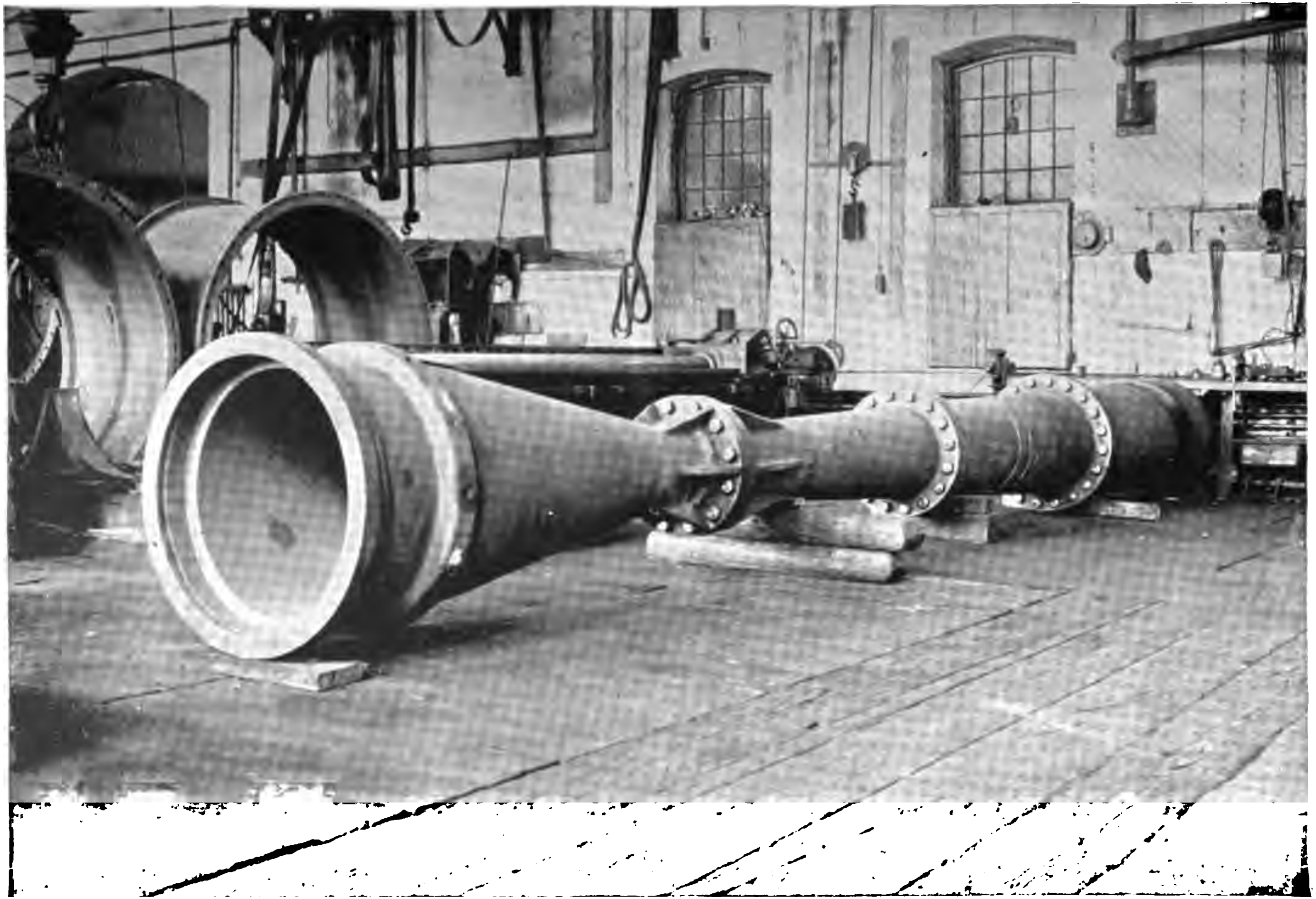
OTHER FORMS OF MEASURING DEVICES.

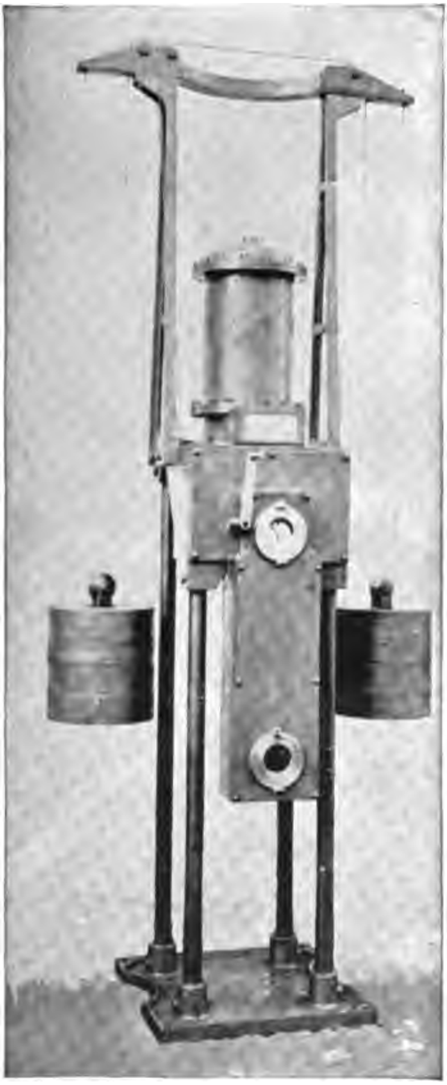
The method of measuring water by causing it to flow through orifices of various sizes under certain heads, is very generally used in the western portion of the United States. We have had about twenty-five different "miner's inches" and while they have undoubtedly served their purpose, it is only a matter of time when their defects and the confusion attendant upon their use will cause their almost complete banishment.

Where water is pumped an approximate measurement may be made by noting the capacity of the pump per stroke, the rate of speed and the time of running. About 10 per cent allowance should be made for the loss due to leakage.

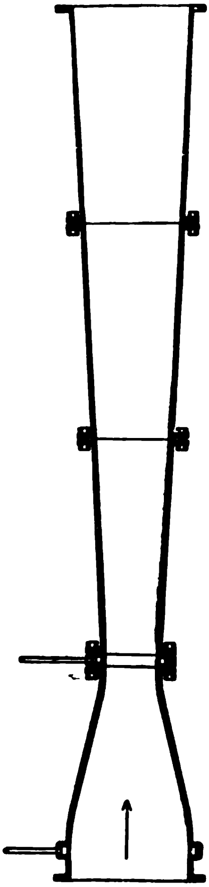
For large canals a measuring flume may be used to advantage. If the amount of water flowing for different depths is once determined by a current meter, a scale showing the depth will be all that is necessary to determine the flow at any subsequent time.

Perhaps one of the most remarkable inventions of the age, in the line of hydraulics, is that of the Venturi water meter. This meter is intended for measuring large volumes of water and is the invention of Mr. Clemens Herschel, a prominent hydraulic engineer of New York. The meter is made in two parts; the TUBE or portion through which the water flows, and the REGISTER for recording the quantity measured. As may be seen by the cuts, the tube consists of two funnels of different tapers. On passing water through the tube it will be found that the pressure is greatest at the up stream end and least at the throat where the velocity is the greatest. At the down stream end the pressure is less than at the up stream end and this difference registers the loss of head in passing through the tube. For a velocity of five feet per second through the throat this loss would amount to 0.05 feet (0.6 inch). A 42 inch meter would pass 5.343 cubic feet of water per second (about 214 Montana inches) with the above loss of head. When the register is not used the amount of water flowing may be determined from a table by noting the difference between the heads as





enturi Meter Registering Device.



The Venturi Meter.

shown by glass tubes at up stream ends and at the throat.

Discussions of the theory upon which this meter is based may be found on pages 466 and 467 of the 9th edition of the Encyclopedia Britannica, and in article 71 of Professor Merriam's treatise on Hydraulics, and in the paper which received the Rowland prize when read by the inventor of the meter, Mr. Clemens Herschel, before the American Society of Civil Engineers, Dec. 21, 1887. While this meter finds its greatest value for city water supplies, yet it has features which commend it for irrigation canals. It may be constructed of iron, wood, brick or other material and of any size.

DIVISORS.

When it is desired to partition the water in a canal so that a certain proportion of the water may be diverted, divisors of a form approximating that in fig. 2 may be used. In measuring water by this method, certain precautions should be taken or the results will be misleading. The velocity of the current in any channel is seldom uniform, being in a straight channel usually greater at the middle just below the surface. In order to give an idea of what may be expected under certain conditions, the following example is given: A number of current meter readings, twenty-seven in all, were taken on the Railey gulch flume of the West Gallatin canal. This flume is sixteen feet wide and the water was running 1.4 feet deep with an average velocity of 1.84 feet per second. The position of each of these readings was plotted on a diagram of the cross section of the flume carefully drawn to scale. The amount of water flowing in a given portion of the flume was then compared with the

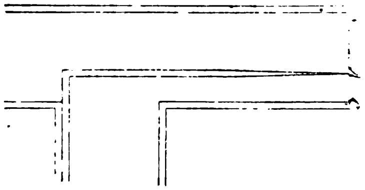


Fig. 2.

A COMMON FORM OF DIVISOR.

amount which would flow if the velocity were uniform throughout. The observations showed that the same amount of water was flowing on either side of the middle of the flume.

In the following table the first column indicates the part of the flume, beginning at the side, partitioned off; the second column gives the percentage of water actually flowing, taking 100 as the amount which would flow if the velocity were uniform throughout the cross section of the flume

Column 1.	Column 2.
1/16	93.44
1/8	93.5
3/16	93.56
1/4	93.66
5/16	94.26
3/8	95.48
1/2	100.00

The above table merely shows what might be expected in a flume where the conditions are similar to the one in which the measurements were taken. If the flume were converted into a divisor the above percentages would be lowered unless some means, such as a slight drop, were used to offset the extra frictional resistance caused by narrowing the channel. Where divisors are used it is desirable to have a slow approaching current with slight drops, one just above and one just below the divisor.

An ordinary screen has the effect of breaking up eddies and tends to make the current uniform. The screen should not be set perpendicular to the direction of the current, but inclined so that the area of the openings will be at least equal to the cross section of the channel.

[redacted]679
M9eb

BULLETIN NO. 7.

MONTANA
AGRICULTURAL
EXPERIMENT STATION

SMALL GRAINS AND POTATOES.

DIVISION OF

Variety Tests of Wheat, Oats, Barley, and Potatoes.---
Analyses of Soil, Wheat, Barley and Potatoes.---
Percentage of Hull and Kernel in Oats.

BOZEMAN, MONTANA, JUNE 1, 1895.

Bozeman Chronicle,
Book and Job Printers,
1895.

MONTANA AGRICULTURAL

EXPERIMENT STATION.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman.
Peter Koch, Secretary and Treasurer	Bozeman.
George Kinkel, Jr., Vice President	Manhattan.
Walter Cooper	Bozeman.
Nelson Story	Bozeman.

EXPERIMENT STATION STAFF.

S. M. Emery	Director and Horticulturist.
Luther Foster, M. S. A	Agriculturist and Botanist.
F. W. Traphagen, Ph. D, F. C. S	Chemist.
W. L. Williams, V. S	Veterinarian.
A. M. Ryon, C E	Irrigation Engineer.

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

Montana Experiment Station,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Experiment Station.

Bulletin No. 7. June 1, 1895.

SMALL GRAINS AND POTATOES.

LUTHER FOSTER.

This bulletin contains the results of the past season's field experiments with small grains and potatoes, together with analyses by Dr. Traphagen, the Station Chemist, showing the composition of several varieties of wheat, barley and potatoes and the average composition of the soil of the Station Farm; also the percentage of kernel and hull in the different varieties of oats. Experience has taught that such experiments must be repeated a number of seasons in succession in order to obtain results of value.

By a continuation of this comparison we hope to determine what varieties of wheat, oats, barley, field peas, potatoes, grasses and other forage plants are best for our climate and conditions, and then produce them in larger quantities, for distribution to the farmers of the state.

In the small grain experiments the plats were made to agree in size with the quantity of seed secured, and they varied from a single row to one-tenth of an acre. Nearly all of them were drilled in rows fourteen inches apart and cultivated often enough to entirely free them from weeds. We hoped by this method to increase the supply of seed sufficiently for more extended work with the best kinds another year.

From Mr. Peter Koch, who has kept a record of the temperature and the moisture precipitation since 1880, we learn that the rainfall of 1894 was above the average and was as follows: April, 2.98 in.; May, 1.95 in.; June, 4.70 in.; July, 2.71 in. This was sufficient to make only one irrigation necessary, which was given between the 19th and 25th of July.

The seeds of the numerous varieties were given principally by Prof. J. H. Shepperd of the North Dakota Station, but Prof. C. A. Zavitz of the Ontario Agricultural College and Prof. C. E. Chilcott of the South Dakota Station, each contributed several kinds. The Glyndon collection of wheat varieties was made by Prof. Willet M. Hays of the Minnesota Station. In a recent bulletin, he writes as follows about the origin of the collection and the present naming: "Through the assistance of the American consuls in Russia and Hungary, many samples of wheats were secured from those countries. Prof. Wm. Saunders, Ottawa, Canada, director of the Dominion experiment farms, and Mr. S. A. Bedford, superintendent of the Manitoba experiment farm, Brandon, made material additions to the list. Mr. C. A. Zavitz of the Ontario Agricultural College, Guelph, and Prof. Luther Foster, then at the South Dakota Agricultural College, also Prof. James Wilson of Iowa Agricultural College, gave us a number of wheats for trial. The 150 samples first collected were planted in 1890 at Warren, Minn. Samples of all the better kinds with others collected were sown in 1891 at Glyndon, ten miles east of Fargo. A fire which burned the station laboratory during the fall of 1890, destroyed letters and other records giving the names of the various kinds of wheat received from Russia and other foreign countries. Consequently, in 1891, the record of each kind was made by using the name of the town where they were planted and our original laboratory entry number, thus: Glyndon 676, or abbreviated to G. 676."

The farm came into the possession of the Experiment Station in the fall of 1893. The ground on which the experiment plats were located had been in cultivation since

1871 without manure. Until 1881 it was cropped every year, but since then it has been summer-fallowed, on an average every third season. The land was plowed in the fall of 1893 and no manure was used in connection with the experiments.

The following is the average analysis of twenty samples of soil taken from different parts of the Station farm.

		PER CENT.
Coarse Material		.60
Fine Material		99.40
ANALYSIS OF FINE MATERIAL.		
Insoluble Matter		80.41
Soluble "		19.59
Soluble Silica	SiO^2	.13
Phosphoric Acid	P^2O^5	.29
Potash	K^2O	.60
Soda	Na^2O	.36
Lime	CaO	1.16
Magnesia	MgO	1.15
Oxide of Manganese	Mn^3O^4	.96
Peroxide of Iron	Fe^2O^3	3.92
Alumina	Al^2O^3	6.15
Sulphuric Acid	SO^3	.11
Organic Matter		4.76
Moisture		4.08

The above constituents represent that portion of each, soluble in hydrochloric acid of 1.115 specific gravity when digested for thirty-six hours, in a steam bath in a tightly stopped flask.

TABLES.

The following tables of variety comparisons show the date of seeding and harvesting, the number of days required for maturity, the yield in bushels per acre and the weight of a stricken bushel. These tables have been arranged for convenient comparison with their corresponding tables of analyses made by Dr. Traphagen.

TABLE I.

VARIETIES OF WHEAT.

VARIETY.	SOWED.	MATURED.	DAYS TO MATURE.	YIELD OF BUSHELS PER ACRE.	WEIGHT OF STRICKEN BUSHEL.
Angus Canadian	May 19	Sept. 12	116	39.2	61
White Russian	" 19	" 12	116	53.2	61
Red Fife	" 18	" 11	116	59.1	62.5
Canadian White Fife	" 19	" 12	116	44.7	61.5
Wild Goose	" 21	" 12	114	33.7	63.5
Junket	" 19	" 12	116	41.9	61.5
Pringle's Champlain	" 19	" 1	105	50.9	62
Red Fern	" 19	" 8	112	44.8	63
Champlain	" 19	" 1	105	44.7	61.5
Blue Stem, S. D	" 21	" 12	114	45.8	62.5
McKissick's Fife	" 19	" 12	116	49.4	62
Warner	" 21	" 12	114	46.4	62.5
Red Fife, S. D	" 21	" 12	114	45.4	62
Old Red River	" 21	" 12	114	36.6	61.5
Bedford's Hungarian Mi	" 19	" 12	116	46.4	61.5
Sutherlin No. 1	" 21	" 12	114	82.5	59.5
Campbell's White Chaff	" 18	Aug. 31	105	39.9	60.5
Ladoga	" 18	" 30	104	63.3	61.5
Assinniboine Fife	" 14	Sept. 11	120	47.	62.5
Bolton's Blue Stem	" 19	" 12	116	35.8	60.5
Snow Ball	" 19	" 12	116	42.6	60.5
Sutherlin, No. 2	" 24	" 12	111	44	58

Varieties of Wheat Continued.

VARIETY.	SOWED.	MATURED.	DAYS TO MATURE.	YIELD OF BUSHELS PER ACRE.	WEIGHT OF STRICKEN BUSHEL.
Summer Cob	May 19	Sept. 12	116	48.7	62
Eureka	“ 21	“ 8	110	45.2	62.5
White Fife	“ 19	“ 12	116	41.5	61
Power's Fife	“ 15	“ 11	119	37.5	62
Red Fife N D	“ 18	“ 12	117	39.9	62
Blue Stem	“ 18	“ 12	117	36.8	61.5
Blount's Hybrid No. 15	“ 14	“ 11	120	45	62
Wellman's Fife	“ 18	“ 12	117	35.4	62
Colorado	“ 15	Aug. 30	107	32.4	61
Saskatchewan Fife	“ 21	Sept. 12	114	41.3	62
Okanagon Valley	“ 19	“ 12	116	36.7	61
Russian	“ 21	Aug. 31	102	45.8	60.5
Kubanka	“ 21	Sept. 12	114	40.9	61
White Fife S D	“ 21	“ 12	114	43.4	60.5
Golden Drop	“ 19	“ 12	116	39	61.5
China Tea	“ 18	“ 12	117	31.2	62
Assinniboia	“ 21	“ 4	106	39.1	63.5
Blount's Hybrid No. 17	“ 18	“ 12	117	33.6	62.5
Silver Fife	“ 14	“ 11	120	39.8	62
California Fife	“ 15	“ 11	119	53.6	62.5
Rio Grande	“ 15	“ 11	119	42.5	62
Haynes' Blue Stem	“ 18	“ 8	113	38.2	62
Club	“ 14	“ 4	113	33.6	
Hungarian Mountain	“ 14	“ 3	112	25.9	60.5
French Imperial	“ 14	“ 4	113	37.5	63
Glyndon No. 113	“ 14	“ 11	120	43.9	62
Glyndon “ 135	“ 18	“ 12	117	41.3	61
Glyndon “ 302	“ 21	“ 4	106	41.9	63.5
Glyndon “ 619	“ 14	“ 1	120	40.6	62
Glyndon “ 636	“ 21	“ 12	114	38.5	63
Glyndon “ 638	“ 18	“ 12	117	33.6	62
Glyndon “ 639	“ 21	“ 12	114	38.5	62.5
Glyndon “ 650	“ 18	“ 12	117	34	62
Glyndon “ 651	“ 14	“ 3	112	22	61
Glyndon “ 663	“ 18	“ 11	116	35.4	60.5
Glyndon “ 664	“ 18	“ 12	117	39.6	61
Glyndon “ 668	“ 14	“ 9	118	36.6	63
Glyndon “ 669	“ 18	“ 12	117	48.8	61.5
Glyndon “ 670	“ 21	“ 12	114	44	61.5
Glyndon “ 673	“ 14	“ 11	120	40.5	62
Glyndon “ 675	“ 18	“ 12	117	33.5	61.5
Glyndon “ 676	“ 19	“ 12	116	34.6	62
Glyndon “ 687	“ 18	“ 12	117	36	62
Glyndon “ 691	“ 21	“ 12	114	47.9	62.5
Glyndon “ 694	“ 15	“ 11	119	32.1	61.5

Varieties of Wheat Continued.

VARIETY.	SOWED.		MATURED.		DAYS TO MATURE.	YIELD OF BUSHELS PER ACRE.	WEIGHT OF STRICKEN BUSHEL.
Glyndon No. 692	"	18	"	12	117	39.8	
Glyndon " 696	"	21	"	12	114	33	63
Glyndon " 697	"	19	"	12	116	40.6	63
Glyndon " 711	"	14	"	11	120	42.5	62.5
Glyndon " 715	"	21	"	12	114	39.2	61
Glyndon " 744	"	21	"	12	114	45.2	61
Glyndon " 747	"	21	"	12	114	35.2	61.5
Glyndon " 748	"	18	"	12	117	41	61.5
Glyndon " 750	"	19	"	12	116	66	62
Glyndon " 958	"	18	"	12	117	46.1	61.5
Glyndon " 761	"	19	"	12	116	44	61
Glyndon " 768	"	18	"	12	117	36.7	61
Glyndon " 773	"	19	"	12	116	49.5	61.5
Glyndon " 774	"	21	"	12	114	35.5	60
Glyndon " 775	"	19	"	12	116	42.2	61.5
Glyndon " 794	"	18	"	12	117	35.4	62.5
Glyndon " 815	"	14	"	4	113	41.7	62.5
Glyndon " 818	"	18	"	12	117	33.8	62
Glyndon " 852	"	14	"	11	120	41.2	62.5
Glyndon " 963	"	14	"	11	120	38	62.5
Glyndon S. D.	"	21	"	12	114	52.6	61.5

TABLE II.

WHEAT ANALYSIS.

VARIETIES.	WATER.	STARCH.	NITROGEN.	CRUDE PROTEIN.
Blue Stem, S. D.	13.10	67.259	1.88	11.750
Wellman's Fife	10.95	70.977	1.86	11.625
Junket	11.10	72.483	1.85	11.562
Sutherlin No. 1	11.75	72.156	1.67	10.437
Colorado	11.25	71.177	1.80	11.250
Glyndon, No. 669	10.96	71.830	1.99	12.437
Bedford's Hung. Mount	11.25	69.871	1.93	12.062
Saskatchewan Fife	10.77	70.850	1.86	11.625
McKissick's Fife	11.26	72.809	1.87	11.687
Power's Fife	11.44	68.402	2.10	13.125
Blount's Hybrid, No. 15	11.24	70.524	1.58	9.875
Pringle's Champlain	11.02	69.544	1.56	9.750
Eureka	11.34	68.218	1.81	11.312
White Fife	11.05	71.667	1.84	11.500
Bolton's Blue Stem	11.40	69.381	1.83	11.437
Glyndon, No. 715	11.15	68.320	1.76	11.000
Blount's Hybrid, No. 17	10.77	66.116	1.87	11.687
White Russian	11.10	68.891	1.85	11.562
China Tea	10.91	67.912	1.69	10.562
Sutherlin, No. 2	10.70	69.626	1.58	9.875
Rio Grande	11.10	68.430	1.95	12.184
Angus Canadian	10.43	70.034	1.87	11.687
Glyndon, 815	10.50	67.640	2.05	12.812
Red Fife	9.90	68.960	2.07	12.937
Ladoga	11.25	67.420	2.00	12.500
Snow Ball	10.10	68.800	1.88	11.750
Russian	11.03	67.120	1.79	11.187
Glyndon, 697	10.88	65.430	1.94	12.110
Golden Drop	10.89	66.670	1.97	12.311
Red Fern	11.14	67.450	1.89	11.812
Assinaboine Fife	10.91	68.690	2.00	12.500
Haynes' Blue Stem	11.05	67.330	1.96	12.250
French Imperial	11.45	64.810	1.96	12.250
Champlain	11.19	67.260	1.90	11.875
Field Wheat, crop of '94	13.67	67.660	1.77	11.062
Early Everett Oats	9.39	56.480	1.63	10.187

TABLE III.

VARIETIES OF OATS.

VARIETIES.	SOWED.	MATURED.	DAYS TO MATURE.	YIELD OF BUSHELS PER ACRE.	WEIGHT OF STRICKEN BUSHEL.
Wide Awake	May 22	Sept. 11	112	18.7	42.4
Bavarian	“ 22	“ 17	118	91.5	41.4
White Wonder	“ 22	“ 1	102	68.1	43.0
Badger Queen	“ 22	Aug. 28	98	59.0	45.5
Improved American	“ 22	Sept. 17	118	46.9	46.5
Black Beauty	“ 22	“ 17	118	69.3	39.0
Early Everett	“ 21	“ 15	117	105.4	41.4
American White	“ 21	“ 17	119	77.3	43.1
Giant Yellow	“ 22	“ 17	118	79.2	38.9
Great Western	“ 22	“ 17	118	88.3	40.6
Black Russian	“ 22	“ 24	125	84.1	39.2
Black Prolific	“ 21	“ 24	126	74.9	40.1
American Beauty	“ 22	“ 15	116	70.7	42.8
Salzer's Welcome	“ 22	“ 17	118	73.7	43.6
White Schœnen	“ 22	“ 17	118	83.3	41.0
Egyptian	“ 21	“ 17	119	103.0	42.5
Poland White	“ 22	“ 17	118	92.8	42.4
Golden Giant	“ 22	“ 24	125	89.0	38.5
White Wonder No. 2	“ 22	“ 17	118	72.9	45.0
White Schœnen No. 2	“ 22	“ 17	118	75.6	41.8
Race Horse	“ 22	Aug. 28	98	88.4	46.2
Salzer's Improved	“ 22	Sept. 17	118	81.7	39.6
New Danish Island	“ 24	“ 24	123	50.1	.....
Archangel	“ 22	“ 15	116	92.8	43.4
Mogheda	“ 21	“ 17	119	84.1	40.6
Progress	“ 22	“ 17	118	82.5	41.6
White Swede	“ 21	“ 17	119	96.3	40.9
Tartarian	“ 21	“ 24	126	85.3	39.6
Prize Chester	“ 21	“ 17	119	109.1	40.1
The Lincoln	“ 22	“ 11	112	104.8	42.7
Lost Stake	“ 22	“ 10	111	74.5	.....
American Banner	“ 21	“ 11	113	84.1	41.9
Giant Yellow No. 2	“ 22	“ 24	125	82.8	38.6
Egyptian No. 2	“ 21	“ 17	119	103.1	41.9
Bland White	“ 22	“ 17	118	82.5	42.3
Archangel No. 2	“ 21	“ 17	119	78.0	42.5
White Canadian	“ 22	“ 17	118	105.4	39.0
White Bonanza	“ 22	“ 24	125	79.9	41.4
Yellow French	“ 22	“ 24	125	59.5	38.1
Race Horse No. 2	“ 21	“ 24	126	73.0	45.4
Lincoln No. 2	“ 22	“ 17	118	82.0	40.9

Varieties of Oats, Continued.

VARIETIES.	SOWED.	MATURED.	DAYS TO MATURE.	YIELD OF BUSHELS PER ACRE.	WEIGHT OF STRICKEN BUSHEL.
American Banner No. 2	May 21	Sept. 17	119	81.7	42.0
Wide Awake No. 2	" 21	" 24	126	68.1	41.6
Badger Queen No. 2	" 22	" 17	118	64.8	45.9
Lincoln Canadian	" 22	" 17	118	92.8	42.0
Jeannette	" 22	" 17	118	103.1	42.1
White Schœnen No. 3	" 22	" 15	115	90.2	41.0
Siberian	" 22	" 17	118	100.5	40.5

TABLE IV.

VARIETIES OF OATS -PER CENT. OF HULL AND KERNEL.

VARIETIES.	WEIGHT OF BUSHEL. POUNDS.	KERNEL. PER CENT.	HULL. PER CENT.
Black Russian	39.2	72.2	22 8
Giant Yellow	38.9	73.4	26.6
Poland White	42.4	73.3	26.7
The Lincoln	42.7	73.0	27.0
Bland White	42.3	73.3	26.7
Mogheda	40.6	73.8	26.2
White Schœnen	41.0	75.2	24.8
Siberian	40.5	74.6	25.4
Giant Yellow No. 2	38.6	73.0	27.0
Black Prolific	40.1	71.9	28.1
Improved American	46.5	75.1	24.9
Black Beauty	39.0	76.1	23.9
White Wonder	43.0	69.7	30.3
Great Western	40.6	74.2	25.8
White Bonanza	41.4	70.3	29.7
White Schœnen No. 2	41.0	74.8	25.2
Lost Stake	....	76.6	23.4
Lincoln No. 2	40.9	74.5	25.5
Egyptian	42.5	70.3	29.7
Prize Chester	40.1	74.6	25.4
American White	43.1	69.6	30.4
Egyptian No. 2	41.9	70.5	29.5
White Swede	40.9	73.0	27.0
Wide Awake	42.4	73.9	26.1
American Beauty	42.8	72.9	27.1
Golden Giant	38.5	73.9	26.1
Archangel	43.4	73.4	26.6
Yellow French	38.1	71.7	28.3
Bavarian	41.4	72.8	27.2
Salzer's Welcome	43.6	70.8	29.2
Canadian Lincoln	42.0	73.8	26.2
White Schœnen No. 3	41.0	74.6	25.4
White Wonder No. 2	45.0	70.7	29.3
Bland White No. 2	....	72.8	27.2
American Banner	41.9	74.4	25.6

TABLE V.

VARIETIES OF BARLEY.

VARIETIES.	SOWED.	MATURED.	DAYS TO MATURE.	YIELD OF BUSHELS PER ACRE.	WEIGHT OF STRICKEN BUSHEL.
Black Hulless	May 21	Aug. 24	95	38.6	....
Moosenay	" 23	Sept. 4	104	58.1	51.5
Hungarian	" 23	" 8	108	60.4	61.0
Chevalier	" 22	" 8	107	43.3	....
Duck Bill	" 23	" 1	101	72.9	52.0
Canadian Black	" 23	Aug. 28	97	71.5	65.5
Improved Black	" 22	" 29	99	61.8	63.5
Manshury	" 22	" 22	92	59.1	49.5
Sutherlin	" 23	Sept. 11	111	59.1	51.5
Kuma Kulla	" 23	" 3	103	46.4	51.5
Manhattan	" 23	" 11	111	68.7	54.0
The King	" 23	Aug. 23	91	30.2	....
Nepaul	" 23	" 24	92	43.1	62.5
Carter's No. 2	" 23	Sept. 11	111	53.4	....
New Zealand	" 23	" 11	111	55.7	....
Highland Scotch	" 22	" 11	112	55.0	....
Champion of Vermont	" 22	" 1	102	41.2	....
Manshury	" 22	Aug. 29	99	44.4	52.0
Salzer's Manshury	" 23	Sept. 1	101	48.7	53.5
Carter's No. 1	" 23	Aug. 27	96	44.3	....
Highland Chief	" 22	" 31	101	53.6	....
Improved Cheyenne	" 22	Sept. 11	112	48.1	....
Imperial	" 22	Aug. 22	92	50.2	....

TABLE VI.

BARLEY ANALYSIS.

VARIETIES.	MOISTURE.	NITROGEN.	CRUDE PROTEIN.	STARCH.	MALT SUGAR.	DEXTRINE.	ASH.
Manshury	10.350	1.650	10.310	62.035	42.431	20.678	2.675
New Zealand	10.675	1.480	9.250	66.606	45.558	22.202	2.715
Carter's No. 2	10.835	1.430	8.940	65.300	44.665	21.770	2.505
Champion of Vermont	10.350	1.760	11.000	64.647	44.218	21.549	2.605
Cheyenne	10.550	1.580	9.875	64.973	44.442	21.657	2.925
Carter's No. 1	10.250	1.690	10.560	61.382	41.985	20.461	2.660
Nepaul	11.075	2.180	13.625	63.994	43.772	21.331	2.175
Imperial	10.250	1.560	9.750	62.035	42.431	20.678	2.575
Highland Chief	10.335	1.570	9.810	65.953	45.112	21.984	2.500
Highland Scotch	10.410	1.500	9.375	69.218	47.345	23.073	2.550
The King	10.250	1.640	10.250	63.341	43.325	21.114	2.910
Black Hulless	10.160	2.100	13.125	66.606	45.558	22.202	2.150
Manshury No. 1	10.575	1.700	10.625	62.69	42.88	20.89	2.610
Duckbill	10.055	1.675	10.469	65.30	44.66	21.77	2.665
Salzer	10.300	1.570	9.812	64.97	44.44	21.66	2.750
Chevalier	10.565	1.550	9.687	66.91	45.77	22.30	2.550
Manhattan	9.650	1.584	9.900	63.01	43.10	21.00	2.665
Manshury No. 2	9.645	1.617	10.106	65.30	44.66	21.77	2.900
Kumma Kulla	10.030	1.763	11.019	64.65	44.22	21.55	2.650
Manshury No. 3	9.915	1.636	10.225	63.99	43.77	21.33	2.710
Sutherlin	10.250	1.646	10.287	58.77	40.20	19.59	2.750
Moosenay	10.415	1.578	9.852	63.34	43.32	21.11	2.550
Lemon Spring Rye	10.975	1.918	12.287	64.97	44.44	21.66	1.760
Altenbraud Spring Rye	13.950	1.617	10.106	66.28	45.35	22.09	1.700

The malt sugar and dextrine are calculated from the starch on the basis of the Normal reaction:

$$C_{18}H_{30}O_{15} + H_2O = C_{12}H_{22}O_{11} + C_6H_{10}O_5$$

Starch + Water = Maltose + Dextrine.

* * *

POTATOES.

The seed potatoes, with the exception of a few varieties, were obtained from J. C. Vaughan, seedsman, of Chicago, Chicago. They were planted the 23d day of May on land that had lain idle for the three preceding seasons. It had been plowed the previous fall and was replowed and thoroughly fitted just before planting. The crop was regularly cultivated and kept free from weeds and bugs throughout the season. Only one irrigation was given, and that about the time the potatoes were setting.

TABLE VII.

VARIETY COMPARISON.

VARIETY.	PERCENT. MERCHANTABLE.	POUNDS PER ACRE. MERCH.	POUNDS PER ACRE. UNMERCH.	TOTAL YIELD.
The Vaughan	90.3	6,549	703	7,252
Rural Blush	79.0	7,455	1,981	9,436
Acme Seedling	90.0	6,083	675	6,758
Lee's Favorite	86.2	9,156	1,465	10,621
Summit	93.3	10,833	767	11,600
Beauty of Hebron	92.0	14,172	1,232	15,404
Arizona	91.4	16,152	1,519	17,671
The Campbell	91.0	9,679	957	10,636
World's Fair	86.5	10,280	1,604	11,884
Alexander's Prolific	93.0	18,611	1,400	20,011
Vanguard	85.0	9,599	1,693	11,292
Rural New Yorker No. 2	90.8	11,645	1,180	12,825
The Freeman	85.3	11,233	1,935	13.168
The Thorburn	87.5	11,492	1,641	13,133
American Wonder (Warner)	90.2	10,941	1,188	12,129
Early Ohio	89.5	7,976	891	8,867
Early Oxford	95.6	16,080	740	16,820
Red Ohio	80.5	5,313	1,287	6,600
Early Polaris	90.7	9,823	1,007	10,830
Reed's Eighty-Six	94.0	12,727	811	13,538
Crown Jewel	91.5	13,494	1,253	14,747
Leviathan	93.5	9,537	663	10,200
Koshkonong	92.7	12,869	1,013	13,882
The Delaware	94.0	16.385	983	17.368
American Wonder (Vaughan)	93.6	18,019	1,232	19,251

TABLE VIII.

POTATO ANALYSIS.

	NAME.	NUMBER OF POTATOES.	WEIGHT.	WATER.	STARCH.	OTHER SOLIDS.
1	World's Fair	6	3.9 lbs	72.34	20.95	6.71
2	Alexander's Prolific	6	3¾ "	75.34	18.80	5.86
3	Summit	5	3⅝ "	75.55	18.93	5.52
4	Leviathan	6	4¼ "	75.62	21.41	2 97
5	American Wonder	6	3½ "	74.33	20.19	5.48
6	Lee's Favorite	7	3⅜ "	75.90	19.27	4.83
7	Freeman	6	2⅝ "	75.50	20.55	3.95
8	Vaughan	6	3⅜ "	77.42	18.26	4.32
9	Rural New Yorker No. 2	5	3¼ "	77.09	19.82	3.09
10	Vanguard	6	2¾ "	78.42	15.40	6.18
11	Red Ohio	6	2⅓ "	78.28	18.11	3.61
12	Acme Seedling	6	3¾ "	77.63	17.71	4.66
13	Beauty of Hebron	5	3½ "	77.93	17.81	4.26
14	Early Ohio	7	3½ "	78.85	16.76	4.39
15	Crown Jewel	6	3⅛ "	73.09	22.26	4.65
16	Koshkonong	6	3¾ "	77.31	19.23	3.46
17	Delaware	6	3 "	76.51	19.44	4.05
18	Polaris	6	2⅞ "	74.00	21.16	4.84
19	Arizona	6	3½ "	78.05	19.09	2.86
20	Reed's '86	6	3⅜ "	78.01	19.73	2.26
21	Early Oxford	6	4⅛ "	77.09	17.62	5.29
	Average			76.39	19.16	4.45

Whole potatoes, including skin, taken for analysis.

CORROSIVE SUBLIMATE FOR POTATO SCAB.

The effects of potato scab on the tuber are so well known and so easily recognized that a description of the disease is not here necessary. Both experimenters and potato growers have successfully prevented the scab by immersing the seed potatoes, for one and one-half hours, in a corrosive sublimate solution, using 2 ounces of the compound to 15 gallons of water. The solution is most readily made by first dissolving the powdered corrosive sublimate in a few gallons of hot water, and then adding enough cold water to make the required 15 gallons.

Since the solution corrodes metals, only wooden vessels should be used. A barrel makes a very good receptacle and the potatoes may be conveniently handled by putting them in coarse sacks for the immersion. If not fairly clean, the potatoes should be washed before dipping; after they have been taken from the solution and dried, they may be cut and planted as usual. The corrosive sublimate is very poisonous and must, therefore, be handled with great care.

At the Station last season, scabby seed potatoes, treated in the manner indicated above, produced a crop entirely free from the disease. Soil, when once infected with scab, will retain the living germs for a number of years, and it is believed that it may become infected from natural drainage and manure, as well as by a scabby potato crop. For such ground the treatment will not be as effective.

It is always desirable to plant clean seed on soil that is free from the disease; but smooth potatoes, apparently free from scab, may have the germs on their surface, if they have been in contact with diseased potatoes. If potatoes are known to be scabby, they should be dug as soon as mature, since the scab continues to grow as long as they are in the ground.

630.679
M9sb

BULLETIN NO. 8.

MONTANA

AGRICULTURAL

EXPERIMENT STATION

SECOND ANNUAL REPORT

OF

TREASURER, DIRECTOR, HORTICULTURIST, AGRICULTURIST,
CHEMIST, IRRIGATION ENGINEER AND VETERINARIAN.

CROP STATISTICS OF GALLATIN COUNTY,
AND
BULLETIN OF PROGRESS UPON THE

PARASITIC ICTERO-HÆMATURIA OF SHEEP.

(Parasitic Red-Water and Jaundice.)

BY W. L. WILLIAMS, VETERINARIAN.

Bozeman, Montana, July 1, 1895.

The Avant Courier,
Book and Job Printers,
Bozeman, Mont., '95.

MONTANA AGRICULTURAL
EXPERIMENT STATION.

LETTER OF TRANSMITTAL.

Bozeman, Montana, July 1, 1895.

To His Excellency, John E. Rickards, Governor of Montana:

Dear Sir: I have the honor to transmit to you herewith in accordance with law, the second annual report of the Montana Agricultural Experiment Station.

Respectfully,
S. M. Emery, Director.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman.
Peter Koch, Secretary and Treasurer	Bozeman.
George Kinkel, Jr., Vice-President	Manhattan.
Walter Cooper	Bozeman.
Nelson Story	Bozeman.

EXPERIMENT STATION STAFF.

S. M. Emery	Director and Horticulturist.
Luther Foster, M. S. A	Agriculturist and Botanist.
F. W. Traphagen, Ph. D., F. C. S	Chemist.
W. L. Williams, V. S	Veterinarian.
A. M. Ryon, E. M	Irrigation Engineer.

Post Office Address and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

Montana Experiment Station,
Bozeman, Montana.

NOTICE: The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Report of the Treasurer of the Board.

The Montana Experiment Station, in account with the United States Appropriation, 1894–95.

DR.

To Receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30th, 1895, as per Act of Congress, approved March 2, 1887	$15,000.00
To Sales Farm Produce	1,039.54
Total	$16,039.54

CR.

By Salaries	$ 3,517.83
Labor	4,586.01
Publications	776.25
Postage and Stationery	77.43
Freight and Express	450.71
Heat, Light and Water	244.84
Chemical Supplies	404.22
Seeds, Plants and Sundries	1,337.46
Fertilizers	375.00
Feeding Stuffs	144.29
Tools, Implements and Machinery	669.65
Furniture and Fixtures	542.84
Scientific Apparatus	560.27
Live Stock	238.35
Traveling Expenses	230.35
Contingent Expenses	94.50
Buildings and Repairs	750 00
Granary, Cellar and Barn	1,039.54
Total	$16,039.54

I hereby certify that the above is a true and correct statement of the receipts and expenditures of the Montana Experiment Station for the fiscal year ending June 30, 1895.

PETER KOCH, Treasurer.

We, the undersigned, duly appointed auditors, certify that we have examined the above account and find it correct.

LESTER S. WILLSON,
ATTEST:—PETER KOCH, Secy. WALTER COOPER.

Dated at Bozeman, this 25th day of June, 1895.

Montana Experiment Station.

Bulletin No. 8. - - - July 1, 1895.

Annual Report of the Director, for the Fiscal Year Ending June 30, 1895.

STATION STAFF.

No change has been made in the membership of the Station Staff, except the addition of A. M. Ryon, E. M., as Irrigation Engineer. Mr. Ryon was the first President of the Montana College of Agriculture and Mechanic Arts, and brings to his new duties a thorough preparation in various engineering branches and a fund of practical experience that will be of great benefit to the Station in the many complex problems that confront the work of irrigation.

STATION FARM.

During the current year, eight acres of unbroken land, upon the north 80 acres of the farm, have been reclaimed; half of this was a swale in which the original soil was wash gravel, too stony for cultivation, it had been permitted to grow up to willows. As a result of 25 years irrigation (the swale being used as an outlet for waste water), the character of the surface soil had materially changed for the better; in breaking it up, surface stone at the rate of 50 loads per acre were gathered from it and the surface well cultivated. It was sown to oats and seeded to medium clover, the oats yielded well and the stand of clover was perfect, with a rank growth, thus demonstrating the ease with which clover can be seeded with grain and also the fertility of land, that was supposedly worthless for farm operations.

The remaining four acres consisted of sage brush soil, heavy loam, overlying a close clay subsoil, stony inplaces. This was broken up in September, well irrigated immediately preceding and following breaking, and rolled down compactly for the winter. In May it was again well irrigated, and by a vigorous use of the disc, harrow, roller and leveler, was put into fair condition for planting, and having a fall of 3° to the north and west it was selected as the most eligible for an orchard site, and is devoted to that use.

An additional water right, calling for one share of water in the Middle Creek Ditch Company, has been acquired, and one half mile of ditch constructed. In connection with the work of irrigation, very satisfactory work has been accomplished with the subsoil plow, manufactured by the Moline Plow Co. This implement deepens and pulverizes the sub soil and thus increases the storage capacity of the soil.

BUILDINGS.

Under resolution of the Executive Board, the proceeds of crops grown on the farm are to be devoted to farm improvements, and in accordance with this, a granary 30 by 35 feet, with a capacity for 6,500 bushels of grain, under which is a frost proof, root cellar of the same dimensions and capacity; also a barn 32 by 50 feet, were erected at a cost of $1,200.

Each building stands upon a solid concrete wall, the materials for which, with the exception of lime and cement, were procured upon the farm.

The outer walls of the superstructures are made of straight pine logs, 6 inches in diameter, from which the bark was removed. The logs cut into short lengths (from 5 to 7 feet), are securely toe nailed into upright posts 6 by 6 inches, which are erected at the corners and points midway between the corners; these posts extend from the foundation to the wall plates. These buildings are substantial, durable, and when painted, present a good appearance. and are built at a very much less expense than frame or brick structures.

Many Montana ranchmen, within reach of timber, can erect very much better buildings of these materials and on the same plan, for less money than either the old style log or frame buildings.

FENCES.

350 rods of fence have been built, the material used being 5 strands best hog tight galvanized wire, and on red cedar posts set one rod apart.

HIGHWAYS.

The county road bi-secting the farm north and south, has been closed and a driveway opened on the west and south lines of the farm.

FERTILIZERS.

1161 loads barnyard manure have been hauled onto the farm in addition to that made upon the farm.

EXPERIMENT PLATS.

A slight change has been made in the location of experiment plats; these have been enlarged until they now comprise 20 acres, and are subdivided by driveways running north and south and east and west through the center of the farm, and connecting with the highways by convenient gates. Upon these gates are placed signs, calling attention to the Experiment farm and inviting visitors to pass through.

Each variety of grains, grasses, roots, and the various tests for plant diseases (scab, smuts, etc.), is indicated by a substantial, white painted stake, upon which, in plain black lettering, is indicated the nature of the experiment. By this system it is possible for the visitor (of which there are many) to gain an intelligent idea as to the nature of the work, without the trouble of looking up a guide to supply the same information that is conveyed by the use of the stakes.

GENERAL FARM CROP.

The following is the acreage and yield of farm crops:

6½ acres Canada field peas, 242 bu., average 37 bu. per acre.

5 acres spring rye, 131 bu., average 26 bu. per acre.

21 acres spring wheat, 628 bu., average 29 bu. per acre.

27 acres oats, 1146 bu., average 42 bu. per acre.

4 acres Lincoln oats, 195 bu., average 48 bu. per acre.

40 acres barley, 1789 bu., average 44 bu. per acre.

6½ acres potatoes, 1131 bu., average 17 bu. per acre

Ninth line should read:

6½ acres potatoes, 1131 bu., average 174 bu. per acre.

judicious crop rotation, the use of leguminous crops and the intelligent application of the usual amount of barn yard manure produced upon Montana farms, that tracts of not more than 160 acres may be farmed continuously without fallowing. The Station Canada field pea crop, grown on land that had been cropped for nine consecutive seasons, to oats, without rest or change, affords evidence of this: this yield was 37 bu. per acre and a considerable per cent of the grain was left in the straw in threshing, also much was shelled in harvesting. The results were most encouraging, all things being considered.

The success attending the field pea crop, not only in the quality and quantity of the grain, but the large crop of nutritious forage from the pea straw, amounting to four tons per acre, valuable both for horses and cattle, demonstrates the ample provision that may be made by the Montana farmer for a cheap and valuable grain food for swine, placing Montana on an equal footing, in this highly profitable business, with the Mississippi valley states.

GALLATIN COUNTY CROP STATISTICS.

Cards of enquiry for return of crop statistics were again sent to owners of farm lands in this county, with the gratifying result that the replies received were 50 per cent greater than those from the crop of 1893.

The size of the average farm is 340½ acres.

The average amount of land under cultivation is 149 acres.

The average amount of pasture land is 171 acres.

The average amount of irrigable land is 191 acres.

The average amount of water used per acre is 1¼ miner's inches.

The average number of times irrigated is 1$^{36}/_{100}$ times.

The average yield of hay, tons per acre, is 1¾ tons.

The average yield of spring wheat per acre is 35½ bu.

The average yield of winter wheat per acre is 41⅚ bu.

The average yield of barley per acre is 50⅙ bu.

The average yield of oats per acre is 61⅓ bu.

The average yield of potatoes per acre is 231¾ bu.

The average yield of field peas per acre is 23 bu.

The three leading varieties of potatoes grown were early rose, white elephant and beauty of hebron.

FARMER'S INSTITUTES.

The lack of funds, and the refusal of the railways to supply transportation to our institute workers, in 1895, curtailed the work. Meetings well attended and full of interest were held at Columbia Falls, Kalispell and Billings. Such work is considered of the greatest importance in states that already stand in the front rank as agricultural producers.

It is to be regretted that the railways are unwilling to grant transportation, as by this means, much could be done to aid the farmer in his work. This service is independent of regular Station work and is cheerfully undertaken in the interest of improved farm methods.

PRESS LIST.

The following newspapers and publications were kindly donated to the Station by the publishers during 1894. These are on file in the Director's office, for the use of the Staff, students and other interested readers:

Elgin Dairy Report, Elgin, Ill.
National Dairyman, Kansas City, Mo.
Southern Cultivator, Atlanta, Ga.
Farm and Home, Springfield, Mass.
American Horticulturist, Topeka, Kansas.
Northwest Magazine, St. Paul, Minn.
Farmers' Guide, Huntington, Ind.
South West Farm and Orchard, Las Cruces, N. M.
American Fertilizer, Philadelphia, Pa.
National Nurseryman, Rochester, N. Y.
Farmers' Magazine, Springfield, Ill.
Northwestern Farmer, St. Paul, Minn.
Northwestern Agriculturist, Minneapolis, Minn.
Farm, Stock and Home, Minneapolis, Minn.
American Agriculturist, New York City.
Gardening, Chicago, Ill.
American Florist, Chicago, Ill.
Hoard's Dairyman, Ft. Atkinson, Wis.
Minnesota Horticulturist, Minneapolis, Minn.
Practical Nurseryman, Huntsville, Ala.
Field and Farm, Denver, Col.
Clover Leaf, South Bend Ind.
Sugar Beet, Philadelphia Pa.
Green's Fruit Grower, Rochester, N. Y.
Weekly Sun, Baltimore, Md.
Wisconsin Agriculturist, Racine, Wis.
Riverside, Red Wing, Minn.
Republican, Lake City Minn.
Dairy World, Chicago, Ill.
Dorset Quarterly, Washington, Pa.
Poultry Monthly, Albany, N. Y.
Farmers' Call, Quincy, Ill.
Independent, Helena, Mont.
Sentinel, Boulder, Mont.
Avant Courier, Bozeman, Mont.
Chronicle, Bozeman, Mont.
Pioneer, Big Timber, Mont.
Times, Billings, Mont.

Gazette, Billings, Mont.
Inter Mountain, Butte, Mont.
Montanian, Choteau, Mont.
Silver State, Deer Lodge, Mont.
New Northwest, Deer Lodge, Mont.
Silverite, Missoula, Mont.
Inter Lake, Kalispell, Mont.
Graphic, Kalispell, Mont.
Tribune, Dillon, Mont.
Examiner, Dillon, Mont.
Western News, Hamilton, Mont.
Leader, Great Falls, Mont.
Tribune, Great Falls, Mont.
Democrat, Lewistown, Mont.
Stockgrowers' Journal, Miles City, Mont.
Yellowstone Journal, Miles City, Mont.
Missoulian, Missoula, Mont.
Mail, Philipsburg, Mont.
Red Lodge Picket, Red Lodge, Mont.
North West Tribune, Stevensville, Mont.
Madisonian, Virginia City, Mont.
Stockman and Farmer, Helena, Mont.
Western Times, Hamilton, Mont.
Rocky Mountain Husbandman, White Sulphur Springs.
The Rockies, Dillon, Mont.
Oregon Agriculturist, Portland, Or.
Sportsmen's Review, Chicago, Ill.
Southern States, Baltimore, Md.
Agricultural South, Atlanta, Ga.
Grange Visitor, Charlotte, Michigan.
Homestead, Des Moines, Iowa.
Montana Fruit Grower, Missoula.
Great Northern Bulletin, St. Paul, Minn.
Market Garden, Minneapolis, Minn.
Nebraska Farmer, Lincoln.
Republican, Missoula, Mont.
Standard, Anaconda, Mont.
The Forester, Mary's Landing, N. J.
Wallace's Farmer, Ames, Iowa.
Success with the Garden, Rosehill, N. Y.
Yellowstone Farmer, Billings, Mont.
Enterprise, Livingston, Mont.
Western Mining World, Butte, Mont.

DONATIONS.

Acknowledgment is hereby made for the following gifts to the Station:

1 package chloride of lime, "Lion Brand," by the manufacturer, Jas. A. Blanchard, New York City.

1 package "Ermisch's Caterpillar Lime," "Owl Trident Brand," by Wm. Menzel & Sons, New York City.

1 hay fork and carrier, by the manufacturers, J. F. Porter & Co., Ottowa, Ill.

1 package "Purple Poison," by H. M. Parchen & Co., Helena, Montana. (Used to destroy potato bugs.)

1 subsoil plow, by the manufacturers, Moline Plow Co., Moline Illinois.

100 pounds bi-sulphide of carbon, by the manufacturer, Edward R. Taylor, Cleveland, Ohio. (This is used in destroying ground squirrels and is a most effective agent in their destruction.)

1 collection plants, from the E. H. Michel Seed & Plant Co., St. Louis, Mo.

1 package rooted grape cuttings, from Olney Taylor, Park City, Mont.

1 peck each of the five leading market potatoes of Greely, Col., from Senator David Boyd, Greely, Col.

1 package of seed and plants of sacaline, from the introducers, A. Blanc & Son, Philadelphia, Pa.

1 copy "Cabbage & Cauliflower for Profit."

1 copy "Potatoes for Profit."

1 package, 33 papers, novelties in garden seeds, from W. Atlee Burpee, Philadelphia, Pa.

1 package garden seeds, from J. C. Vaughn, Seedsman, Chicago, Ill.

1 package seed corn, R. W. Main, Seedsman, Cando, N. Dakota.

1 package hardy shade trees, from Prof. Sam'l B. Green, St. Anthony Park, Minn.

1 package garden seeds, from Henry A. Dreer, Seedsman, Philadelphia, Pa.

1 package seed corn, from Oscar H. Will, Nurseryman and Seedsman, Jamestown, N. Dakota.

1 complete set "Holstein Friesian Herd Books," from F. L. Houghton, Secy., Brattleboro, Vermont.

1 complete set Reports Oregon State Board Horticulture, from Com'r Henry E. Dosch, Hillsdale, Or.

1 sack seed potatoes, "Gallatin Beauties," from J. B. Weaver, Belgrade, Mont.

1 complete set Reports Missouri Botanical Garden, from Prof. Wm. Trelease, St. Louis Mo.

Liberal deductions from regular prices were made by A. V. Cleland, Minneapolis, Minn., for a fanning mill; also by Kemp & Burpee, Syracuse, N. Y., for 1 manure spreader.

BULLETINS.

Three Bulletins, regular series, and two Bulletins for the Press, have been issued for the year ending June 30th, 1895, with titles as follows:

Bulletin No. 5, "First Annual Report," 18 pages, 5,000 copies.

Bulletin No. 6, "Measurement of Water," 24 pages, 5,000 copies, by A. M. Ryon.

Bulletin No. 7, "Small Grains and Potatoes," 18 pages, 5,000 copies, by Luther Foster.

Press Bulletin No. 3, "Potato Scab," 1 page, 3,000 copies, by Luther Foster.

Press Bulletin No. 4, "Request for Sample Grasses," 1 page, 2,000 copies, by F. W. Traphagen.

Many names have been added to the mailing list during the past year, by residents of Montana.

REPORT OF THE HORTICULTURIST.

The Station farm does not afford a representative orchard site as compared with the average Montana farm, the variation from level being too slight and the soil containing too strong a per cent of black loam, or vegetable humus. The land selected as a site being new, with a shallow depth of pulverized soil, dynamiting was resorted to upon half of the tract to obtain a comparison as to results in root development between soil dynamited and untreated. This was done as follows: Two-inch holes were drilled to a depth of 4½ feet, in which were placed quarter-pound dynamite cartridges to which were attached sufficient lengths of fuse to admit of the safe discharge of the cartridges. The holes were filled with earth and thoroughly tamped. The explosion effected a complete mechanical disintegration of the soil for many feet in all directions from the hole. Two results will thus be attained—a porous, friable soil much sooner than would result from cultivation, and an abundant moisture storage system.

Believing that fruit growing offers great promise in Montana, it is the wish of the horticulturist to offer every assistance in the work that is to be achieved by practical, painstaking effort. It is comparatively but recently that fruit has been set for profit. The few who have been successful in fruit growing are those who have been planting for many years and have developed a system of their own. These have set out many varieties, and owing to the carelessness and dishonesty of many nurserymen there are many misnamed sorts doing fairly well. This of itself adds to the perplexity of the situation, as newly set orchards if filled with trees ordered under a misconception as to names of varieties will in fruiting be a disappointment to the planter. Under these circumstances it has seemed necessary to experiment with a much larger list of varieties than would be otherwise required in order to effectually demonstrate such kinds as are hardy and desirable as to quality and season.

The following trees and plants were set:

243 apples and crabs, 73 varieties.
74 plums, 24 varieties.
20 prunes, 4 varieties.

74 cherries, 22 varieties.
9 apricots, 3 varieties.
125 currants, 4 varieties.
75 gooseberries, 3 varieties.
75 blackberries, 3 varieties.
150 black raspberries, 6 varieties.
200 red raspberries, 8 varieties.
50 dewberries, 2 varieties.
3500 strawberries, 54 varieties.
1700 evergreens, 14 varieties.
3500 deciduous trees, 12 varieties.

Better results in planting could not have been asked, losses being but trivial and confined almost exclusively to raspberries and evergreen seedlings.

Many perplexing problems are met in fruit culture in Montana, the high altitude (4,891 feet at Bozeman) compelling the use of means for prevention of injury to early blooming sorts, chinooks in the winter months, variable and uncertain seasons, late and early snow storms—all undesirable factors in fruit growing. On the other hand, the superior quality of the soil, the long sunshiny summer days, the protracted fall season and the abundance of water for irrigation, these considered with the protection usually afforded by the proximity to the mountains, are most favorable qualities entering into the merits of the case.

Intelligent care and protection will be extended to the Station orchards and it is thus hoped to achieve results that will, to say the least, be a guide to those engaged in orcharding. Respectfully submitted,

S. M. EMERY.

REPORT OF THE AGRICULTURIST AND BOTANIST.

To the Director:

Sir: Since my last report, the work for the season of 1894 has been completed and such results as seemed suggestive to the farmers of the state, have been published in Bulletin No. 7, under the title of "Small Grains and Potatoes." This Bulletin contains the results of the variety comparisons of wheat, oats, barley and potatoes, the percentage of kernel and hull in the different varieties of oats, together with analyses, by the Station Chemist, showing the composition of numerous varieties of wheat, barley and potatoes and the average composition of the soil of the Station Farm. It includes also concise directions for the treatment of seed potatoes with a corrosive sublimate solution for the prevention of potato scab.

The tests of buckwheat, millet, spring rye, field corn, field peas, grasses, clovers and other forage plants were not sufficiently complete to warrant a report of results until a repetition of the work has been made.

Experience teaches that field experiments must be often duplicated and many times repeated in order to obtain reliable average results, hence the plat work undertaken this season is, in the main, a repetition of the experiments of 1894, with numerous important extensions and additions.

The following brief outline shows the work now in progress:

VARIETY TESTS AND COMPARISONS.

This line of experiments includes 33 kinds of winter wheat, 2 of winter rye, 87 of spring wheat, 2 of spring rye, 50 of oats, 28 of barley, 64 of potatoes, 4 of field peas, 25 of sweet corn, 17 of field corn, 2 of broom corn, 1 of sorghum, 2 of millet, 4 of clover, 20 of grasses, 2 of sugar beets, 17 of mangles, and 10 of carrots. In nearly all cases the varieties selected were believed to be those most likely to give good results under existing conditions of soil and climate.

By a continuation of the careful comparisons and selections in the variety tests, we hope to determine what varieties of wheat, oats, barley, potatoes, field peas, grasses, clovers, and other forage plants, are best adapted for general cropping in the state, and when practicable, as in most field crops, produce the pure seed of those superior kinds in quantities for distribution among the farmers.

FALL SEEDING OF SPRING WHEAT.

A variety of hard spring wheat, known as Yellowstone fife, was sown at regular intervals, beginning the ninth day of August and ending the nineteenth day of November. Altogether fifteen sowings were made, the object being to determine the practicability of such seeding and the time to sow for best results, and to compare the quality, yield and other characteristics of spring wheat sown thus out of its natural season, with that sown in the spring.

THICK AND THIN SEEDING.

Wheat, oats and barley were sown in series of duplicate plats of one-twentieth acres each, to find what quantity of seed per acre gives the best results. In wheat, the amount of seed varied from two to twelve pecks per acre; in oats, from four to sixteen pecks; and in barley, from two to fourteen pecks. With oats the depth of seeding was also considered, each series referred to above being planted at a different depth. This varied from two to five inches.

FLAX.

Weekly sowings of flax were made thro' the month of June, to determine how late the seeding may be done and still secure a crop without damage from fall frosts.

METHODS OF POTATO PLANTING.

In addition to the potato variety comparison mentioned above, the following tests in methods of planting were made:

Shallow versus deep planting, the depth varying from two to ten inches; potatoes cut and planted the same day versus potatoes cut five and ten days previous to planting; heavy seeding versus light seeding, the quantity per hill ranging from a single eye cutting of a small potato to two large whole potatoes and the distance between hills, from six inches to three and one-half feet; drills versus hills; cuttings versus whole potatoes; whole large potatoes versus whole medium or whole small potatoes; cuttings from large potatoes versus cuttings from medium or small potatoes; seed ends off versus seed ends on; one eye cuttings versus two eye cuttings; machine cutting versus one eye and two eye cuttings.

PIG FEEDING.

A short experiment was conducted during the fall which embraced the following questions:

Whole wheat soaked versus ground wheat soaked. Whole peas soaked versus whole wheat soaked. Ground wheat fed dry versus ground wheat soaked. Whole peas soaked versus ground wheat soaked and dry.

EXPERIMENTS IN PROGRESS.

Ground barley versus ground wheat, both fed dry. Mixed foods versus single foods, the mixed food consisting of wheat, peas and barley; the single foods, barley at one pen, and wheat at another. Mixed foods versus the same foods fed singly successive weeks. A grain ration with green foods, such as alfalfa, pea vines or clover versus a grain ration without the green stuff. Green food alone versus the same green food with a grain ration.

PLANT DISEASES.

SMUTS.

Treatment for smut in wheat, oats and barley were made as follows:

The seed grains were immersed for different lengths of time, in hot water of various degrees of heat, according to the kind of seed treated. For wheat the temperatue varied from 128° Fah. to 140°, the length of immersion ranging from three to fifteen minutes; for barley from 124° to 140°, the time from three to ten minutes; for oats from 126° to 150°, the time ranging from dipping long enough to thoroughly wet the seed, to ten minutes.

Seed wheat was also treated with a copper sulphate (blue vitrol) solution varying in strength from one pound of copper sulphate to one gallon of water, to one pound to five gallons of water.

The following solutions ranging in strength from 1/5 per cent to 5 per cent were also used in the treatment of seed oats and barley for smuts: Corrosive sublimate, potassium sulphide, zinc chloride, zinc sulphate, potassium bicarbonate and potassium permanganate.

POTATO SCAB.

This experiment included not only the prevention of scab, but also the treatment necessary to secure a crop free from the disease even though the seed be badly infected.

In this treatment the solutions used were the same as those mentioned for the treatment of smut in oats and barley, the strength varying from 1/10 per cent to 5 per cent, and the period of immersion ranging from a few minutes to thirty seven hours.

GRASS AND WEED COLLECTION.

In compliance with the request sent out by the Station Chemist, for samples of native grasses and noxious weeds, I have undertaken to make a collection of all weeds and grasses growing on the Station farm, for the Station and College herbariums, and to determine the same.

As soon as practicable, it is the intention to send out in bulletin form, a descriptive list of the most valuable native grasses and the most dangerous weeds, with methods for the extermination of the latter.

Respectfully submitted,
LUTHER FOSTER.

REPORT OF THE CHEMIST.

To the Director:

Dear Sir: The following brief outline shows the work done by the chemical division during the past twelve months:

Twenty-one samples of soils have been analyzed, as a preliminary to the study of soils from all parts of the state.

Much time has been given to an effort, in connection with the Committee on the Analysis of Soil and Ash, of the Association of Official Agricultural Chemists, to secure analytical methods which will give harmonious results in the hands of different chemists, and which will at the same time give a fair idea of available plant food contained in the various soils. This is far more than can be said of the present methods.

There has been a very generally prevailing belief that potatoes grown with irrigation are inferior, containing very large percentages of water, and this idea has been circulated to the detriment of the Montana product.

The investigation of this matter, undertaken upon your suggestion, has demonstrated that the Montana potato not only contained no more water, but actually contains less than potatoes grown without irrigation. This may be a seeming paradox, but it is nevertheless true.

The average of a large number of Montana potatoes was, water, 76.39 per cent, and of starch, 19.16 per cent, while the results obtained from a number of varieties from other states, analyzed under the same conditions was, water, 77.21 per cent, and starch, 17.49 per cent.

This should effectually dispose of the objection that irrigated potatoes are inferior.

In connection with my investigation of the effects of tailings waters from silver mills, I have analyzed a great many samples of water. This experiment is progressing favorably, and a number of interesting facts have already been developed, but it will require at least one more season of pot or plat experiments before a bulletin can be issued.

Twenty-two samples of barley have been analyzed, to learn which give best results with Montana soil and climate, and to suggest the best varieties to be planted. These rerults will appear in the bulletin on farm crops, together with the analyses of two samples of rye, thirty-five samples of wheat, and one of oats.

Miscellaneous analyses have been made, covering clays, marls, waters for drinking purposes, flour, gypsum, limestone, and milk.

Much time has been spent in a study of analytical methods.

Mr. Cobleigh has rendered willing and effective service.

Very respectfully yours,
F. W. TRAPHAGEN,

REPORT OF THE IRRIGATION ENGINEER.

To the Director:

Sir: My connection with the Station Staff dates from July first, 1894. Since then about one-half of my time has been devoted to Station work, the remainder being occupied by College duties. It will be readily seen, however, that a large part of the study and investigations necessary for the proper conduct of either one of these departments is of direct utility to both, and that a thorough scrutiny of general engineering and other publications which may have any bearing on irrigation, form no small part of the work.

Our College and Station introduces a line of work which is new to a large part of the community and which I believe is not thoroughly understood by many. It is difficult for the average man who spends from eight to ten hours per day in the field or at his office and has a definite amount of work performed which he can show at the finish, to comprehend that an instructor or an investigator in the sciences must spend many hours a week in abstract study, or suffer the penalty of rapidly falling behind in his profession. This study really consists in following the experiences and investigations of others, not only in his own line of work but to a certain extent in branches which may have only a remote bearing on his profession. The investigator or instructor in the sciences whose entire time is taken up by routine work in the class room or office must necessarily occupy a low rank in his profession.

The average layman has not sufficient time or money to enable him to indulge in experimental work along certain lines; neither has he the time to acquire to any great extent the general knowledge of scientific principles which is absolutely essential to many investigations.

Our Station Staff consists of a number of men educated in the sciences, each of whom gives his special attention to one or more branches of the agricultunal industry. It would seem fitting that one member should devote his time to that particular branch which makes farming a possibility in the arid west.

While no scientific demonstrator is required to emphasize the value of water to the western farmer yet it certainly cannot be truthfully asserted that irrigation practice in the west has reached perfection. In fact it is generally admitted that our irrigation laws are defective. The holders of water rights, fearful of additional litigation, are naturally conservative and prefer to adhere to present systems even if they are confessedly imperfect, rather than to experiment with new ideas or introduce methods not thoroughly understood by them. Our Station can do much in this direction towards educating the people by publishing accounts of the practice in other older countries, as well by keeping abreast of the progress in our own country.

The Montana Society of Civil Engineers has shown a disposition to co-operate with the Station in this direction and they have already done some excellent and effective work The United States Geological Survey has also taken the Station into partnership and exchanged favors.

During the past year the work of the department has included the design and superintendence of the construction of the Experiment Station Building; general surveying and engineering work connected with the farm, such as laying out plots, running ditches, fences, etc., etc. Some work has also been done in measuring the water in various canals with the view of collecting information concerning the value of coefficients of friction; determining proper velocities from observations; of scour, deposit of sediment and economic considerations, as well as compiling data on the duty of water: While acting as a committee on the measurement of water for the Montana Society of Civil Engineers, I made a number of experiments for the purpose of determining the value of our Statutory inch, expressed in cubic feet per second, for openings of various sizes. These experiments demonstrated that the Statutory inch of water is not a constant quantity, but a quantity increasing as the orifice is lengthened. The report made to the Society in December, 1894, also called attention to various defects in the Statute which defines the method to be pursued in measuring water, and suggested a substitute for the existing Statute. The report was published in full in the Journal of Associated Engineering Societies for January, 1895 and was copied or abstracted by the Engineering Record, American Engineer and Contractor and other publications. A bill was introduced in the legislature with the object of remedying the present defects. The bill passed the Senate but was defeated in the House.

The work of the year has also embraced the publication of Bulletin No. 6, on the Measurement of Water. An abstract of this Bulletin will shortly appear in the Irrigation Age. Experiments have been made with a device for securing a uniform flow of water in laterals when the head of water in the main canal fluctuates, the results of these experiments will be published later.

This office has effected arrangements with the Division of Hydrography of the United States Geological Survey, whereby the writer has charge of all river measurements and observations made by the survey in Montana. The method of conducting this work is as follows: The survey has established gauge posts at various stations; local observers read the height of the water on these posts twice every day, and send a report to this office every week. At certain stages of the water, indicated by these reports, the amount of water flowing in the river is determined with a current meter, and from the data so obtained a rating table is prepared from which we can estimate the flow for any day of the year. The U. S. Geological Survey furnishes money for the payment of the observers and also for the expenses attendant upon taking the gaugings. I have trained a young man, Mr. Peter Seih, to do this latter work. My duties consist in maintaining an oversight and directing the work in this State. Payments to the observers and the assistant are also made by me as agent for the U. S. Geological Survey.

During the year, fifteen gaugings have been made, and records kept of the flow of the Jefferson River, at Sappington; the Madison River, at Three Forks; the Gallatin River, at Logan; the West Gallatin River, at Williams' Ranch, and of Middle Creek, near the mouth of the Canyon.

Daily records of maximum and minimum temperatures, together with the rain and snow fall and percentage of humidity are taken and the information is kept on file for reference.

The subject of road making, improvement and maintenance has received considerable attention, and a general report on the relative values of different pavements was submitted to the Bozeman City Council. This report was printed in the Bozeman Chronicle. Another article of a more popular character was published in the Good Roads Magazine for 1894. While the greater part of Montana is favored with exceptionally good natural roads, there are sections like the fertile Gallatin Valley where the roads become almost impassable during the wet spring and fall seasons. For such districts the subject of road improvement must always be an important one and ought not to be neglected by our Station.

Respectfully submitted,

A. M. RYON,

RERORT OF THE VETERINARIAN.

TO THE DIRECTOR:

DEAR SIR: As Station Veterinarian, I beg to report that the major portion of my time during the past year has been expended in completing the work on Bulletin No. 4, which was unavoidedly delayed; in collecting the material for and preparing report for publication on the *Parasitic Ictero-Hæmaturia* of sheep, which appears in this Bulletin, and in investigating diseases of sheep, due to animal parasites, chiefly the larvæ of *œstrus ovis* or gad fly, and tape worms, and a disease of fowls due to an internal parasite—cytodites nudus.

It is hoped that bulletins will be ready upon the two latter topics in due course of time.

Other minor investigations have been made, notes upon which are duly filed in my department, but they are as yet too fragmentary to prove of public interest.

The work of my department is progressing satisfactorily with abundant material for investigation and the stock owners willingly cooperating at every opportunity.

Respectfully submitted,
W. L. WILLIAMS.

PARASITIC ICTERO-HÆMATURIA OF SHEEP.

(PARASITIC RED-WATER AND JAUNDICE.)

BY W. L. WILLIAMS.

It has been thought desirable to publish, in brief form, the results of some investigations of a parasitic disease of sheep—hitherto undescribed in America—chiefly with a view to placing veterinarians and flock-masters on their guard that they may recognize or suspect the nature of the malady when present, and thus lead to a more complete study regarding its extent, cause, nature and prevention.

The investigations conducted by this station were preliminary and serve only to identify the disease as that described under the name of "Carceag" or "Parasitic Ictero-Hæmaturia of Sheep" in other countries, further study being prevented for the time, by an abatement of the malady which apparently occurs annually in early spring, and partly because the work was undertaken a long distance from the laboratory, with insufficient equipment at immediate hand.

An impression has been formed that almost all losses among sheep in the Rocky Mountain States were due to the larger animal parasites—such as tape worms and the sheep gad-fly (œstrus ovis), or "grub in the head"—and while the impression may be true, it apparently does not fully apply to Montana; for so far as this station has been able to learn, greater losses have occurred during the past four years from *ictero-hæmaturia* in one little valley, than has been produced by the larger animal parasites in the balance of the State. But this is perhaps more apparent than real, the losses from the larger animal parasites being wide spread and continuous, although rarely if ever producing in one locality so sudden and serious loss.

While the disease so far as recognized is apparently local, if we are to judge from the losses hinted or recorded among sheep in other Rocky Mountain States, it is not improbable that this disease exists as a serious scourge in other similar localities.

The disease is due to a microscopic animal parasite very similar in many respects to the parasite of Texas fever of cattle, and has been found in the blood, urine, liver, spleen and kidneys.

The attention of the station was first called to this malady in a note addressed to the Veterinarian, under date of January 25, 1895, by T. Clowes Miles, Esq., of Silver Bow, who stated that for some three years a peculiar and fatal malady of sheep had existed in his vicinity which he believed was a disease "of the kidneys, gall and liver."

The disease seems to have attracted the official attention of the State Veterinarian as early as 1892, who, in his report for that year, refers to an outbreak of "anthrax" among sheep in the Deer Lodge Valley, without appending any description of the disease as observed, or in any way giving his grounds for diagnosis, while the sheep owners claim that the same disease investigated by this station has recurred annually since 1891, and that it is identical with the malady described as anthrax, in 1892.

Later the matter was referred to in the Bureau of Animal Industry of the U. S. Department of Agriculture, and by their advice it was eventually brought to our attention, and a personal visit was made to the infected locality in Deer Lodge and Silver Bow valleys on March 25, this year (1895).

The history of the disease, as related by the sheep owners, dates back to 1891. Since that time it has appeared annually in a district covering about 300 square miles, comprising the upper portion of the Deer Lodge valley, the lower portion of Silver Bow valley, and the surrounding foot-hills and mountains.

Sheep grazing was begun in the infected area early in the settlement of the territory, sheep having been brought to the valley as early as 1875. All the losers in the recent outbreak engaged in the industry prior to 1882, their flocks remaining quite healthy, their losses being confined to occasional deaths from the larger animal parasites and accidental diseases; until in 1891, when a fatal epizootic appeared almost simultaneously in four or five large flocks of 2,000 to 10,000 each, since which time the losses have been very serious, averaging, as nearly as can now be learned, about 2,000 sheep annually, more than 80 per cent of which may be safely attributed to this affection.

The losses were so serious that one of the largest owners disposed of the entire remnant of his flocks after some two years. Another has just sold his entire flock to butchers, and still other losers have greatly reduced the remnants of their flocks by selling to butchers all animals apparently fit for mutton, so that there are now grazed in the infected territory less than 20 per cent of the number kept there in 1891.

The Deer Lodge valley and its tributary, the Silver Bow, situated on the Pacific slope of the Rocky Mountains, has an altitude of a little more than 5,000 feet, with the foot-hills and mountains on either side extending 500 to 1,500 feet higher. The valley soil is highly alkaline, the alkalinity at some points preventing the growth of vegetation. In some places it is boggy, but generally dry, semi-arid, rendering irrigation necessary for the production of hay and cereals.

In winter the sheep are fed on hay cut from these valley-lands, or grazed upon the meadows, and watered from the valley streams; while in summer time they are grazed in the foot-hills and mountains, and watered at mountain springs, which are usually surrounded by alkaline bogs.

The smoke from extensive copper smelters in the cities of Butte and Anaconda is habitually carried by the wind over into the infected area, leading some sheep owners to attribute their losses to smelter fumes. But the smelters had existed for eight or ten years before the malady appeared, and even now only sheep and goats are affected while other animals in the same district remain healthy.

The disease generally appears late in autumn, long after mountain grasses have ceased to grow and are wholly dried up, except in the alkaline bogs about the springs; rages somewhat seriously for a time, then abates during the cold winter months to again become more severe in late winter and early spring, then disappears until the following autumn.

SYMPTOMS.

At the first objective signs of the disease, the sheep drops behind the flock, ceases to graze, moves unsteadily, with back arched, and appears listless.

The symptoms develop rapidly, a moderate fever is present, and the shepherd soon notices characteristic changes in the urine, which assumes a distinctly reddish, bloody or reddish-brown color. The visible mucous membranes (lining membrane of eyelids and nostrils) are quite yellow, and in well-marked cases, if the fleece be parted, the skin is found to have a well-marked yellow color, indicating severe jaundice.

Dropsical swellings are occasionally seen on the sides of the head and neck. The patient lies down most of the time, in a crouching position. In those cases where the disease has become well developed and the red-water and jaundice are plainly present, it appears to prove universally fatal, death ensuing within one to five days after the first symptoms are observed.

Death is usually preceded by collapse continuing for several hours; at times, however, convulsions may occur in the last stages of the affection.

It seems that not all affected sheep show evident signs of the disease while alive, as it appears that many of them, which were slaughtered by local butchers, were in apparent health, and the evidences of disease passed unnoticed until after slaughter, when the general jaundice was so evident as to lead the butchers to denominate the affected flocks as the "gold brand" sheep.

Post-mortem examinations upon the bodies of ten sheep, some recently dead, others killed when in the last stages of the disease, revealed quite uniform pathological (disease) changes.

The degree of emaciation (poorness) or fatness varied, but generally no marked emaciation was present. Most of them were moderately, others decidedly fat.

It appeared that emaciated (poor) sheep were most likely to escape infection, and that those in moderate or high condition succumbed too quickly to the malady to lose much in flesh.

The skin, connective and adipose (fatty) tissues throughout the body had a very marked yellow color, at times pale, at others a bright, almost lemon color. *The muscles* were pale, soft, faintly yellowish.

The blood in sheep which had recently died was found thin; only feebly if at all coagulated (clotted), and quite pale in color. When animals in the last stages of the disease were killed by bleeding, the escaping blood was found very scant, thin, watery, coagulating feebly, if at all, pale, and differing in acute cases from the pale blood of ordinary anemia (bloodlessness) by assuming a light, dirty, grayish-red color.

The digestive organs offered nothing special, containing little food, as a rule, and partaking to a moderate degree in the general yellow color.

The liver, when showing deviations from the normal size, was a little contracted, weighing two to two and one-half pounds in sheep forty to sixty pounds weight; the jaundice, so common throughout the body, was especially marked in the liver, the color varying from a pale yellow to yellowish-brown externally, while internally it presented a brighter yellow, at times almost orange color. A cut surface was smooth, very moist, the lobuli appearing very distinct. The liver substance was very friable, and upon breaking, the lobuli were yet more apparent than upon the cut surface. The gall bladder was usually found well filled, frequently distended with a yellowish-green, or more often chocolate-colored or green black, thick, flocculent bile.

The kidneys were very much enlarged, weighing twelve to sixteen ounces or more, the capsule easily detached, the parenchyma (proper tissue or pulp) dark, dirty-black or blue-black, soft, easily torn, and when cut, large quantities of bloody or chocolate-colored urine oozed from the cut surface upon very slight pressure.

The urinary bladder was in some cases empty, more generally filled with bloody or chocolate-colored urine.

The ventricles of the heart were in some cases filled with imperfect blood clots, in others empty. The pericardium (heart sac) and endocardium (heart lining) were frequently ecchymosed. In one case the pericardium contained a firm gelatinous clot of a bright-green color one inch long by one-half inch thick, and in the same case there was a considerable effusion (collection of liquid or dropsy) of green serum above the left kidney.

Effusions in connective tissue spaces (spaces in the loose, white fibrous tissue between the skin and muscles and in spaces between the muscles) in various portions of the body are not uncommon; generally of a yellowish or yellowish-green color, and occurring most frequently along the sides of the head and neck, on the inside of the thighs, or within the body cavity.

The spleen (melt) appears contracted, more spherical than usual, weighs two to three ounces, firm, pulp dark reddish-brown.

The long distance from the laboratory and insufficient apparatus carried, prevented an extended microscopical study of the disease, confining the work almost wholly to the fresh blood.

The examinations were made with a Zeiss one-twelfth homogeneous immersion objective, ocular three.

The first marked change noted in the blood was a great decrease in the number of red blood cells and a corresponding increase of the white cells—there being, in extreme cases, one of the latter to four or five of the former. The normal ratio between white and red blood cells is one of the former to 300 to 500 of the latter.

The red cells were very much enlarged, swollen, turgid, their borders irregular, crenate; they were no longer bi-concave, but bi-convex, or spheroidal. Their usual sharp contour was wanting, their appearance dull, lustreless, and although some examinations were made as quickly as possible after withdrawal of blood from the vessels of living animals, no movement of the cells could be seen. Within the red blood cells were seen numerous round, oval or sometimes oblong and curved bodies one-tenth to one-sixth the diameter of the red blood cells. In some of these cells but one of these bodies was to be seen, in others there were two to four, some apparently in process of division. These bodies were motile, at times moving from one portion of the blood cell to another, either across its surface or from the surface into the interior. Some parasites were seen free in the blood serum, others could be seen leaving the blood cells, becoming free in the serum, while still others could be seen entering the cells from the serum. These bodies readily stained with aniline red and methylene blue.

This affection has been but recently described, and, so far as known, by but two observers. The parasite seems to have been first discovered by Prof. V. Babes, of Bucharest, Roumania, in 1888 (Virchow's *Archives B.* 139 S. 384); and the histological changes described by him in 1889 (*Ib.* 1889); and in 1892 (*Compte rende. de L, Academie des Sciences*) he described the parasite as one apparently occupying a middle ground between bacteria and protozoa. Professor Babes denominated the disease "Carceag." His efforts at cultivation of the parisite were followed by negative results.

We next find the disease described in 1895 by Professor Dr. A. Bonome (Virchow's *Archives B.* 139, S. I.) of the Royal University at Padua, Italy, as Parasitic Ictero-Hæmaturia of Sheep.

The symptoms and post-mortem appearance as seen by Dr. Bonome are identical with those recorded above as seen in this State.

The microscopical appearances noted in the blood of the affected sheep in the Montana outbreak are also fully identical with those observed by Dr. Babes and Dr. Bonome in Roumania and Italy.

Dr. Bonome made a careful study of the disease in the living animal at his laboratory, and in addition to the points included in our investigation, made an extended microscopical study of the liver, spleen, kidneys and urine, besides making ineffectual attempts at experimental transmission of the disease to healthy sheep, by means of the transfusion of blood from those affected.

The most noteworthy changes observed by Dr. Bonome in any organ were those of the liver, in which the hepatic (liver) cells early undergo necrobiosis (death); some are swollen, turgid, yellow and without nuclei (kernels); in others nuclei are to be seen, affected with dropsical effusion. The affection of the liver is general and severe, large sections showing no unaffected liver lobuli; some were even completely destroyed, leaving a cavity filled with cell debris.

The parasites were numerous in the liver, invading the cells and appearing among the cell debris in the intra-lobular veins and the bile capillaries.

The spleen seemed especially rich in parasites, they being found in abundance in the contained red blood cells, in the pulp cells and in a free state.

In the kidneys he found the epithelial cells lining the tubuli (the little tubes in which the urine is secreted) in a state of fatty degeneration. In the glomeruli (tufts or nodules at beginning of the tubules) the arterial loops were in many cases distended and blocked up by emboli (clots) of red blood cells, other loops were destroyed by the emboli and in some cases almost the entire glomerulus was destroyed and the cavity occupied by detritus consisting of the remnants of the arterial loops and broken-down red blood cells. Dr. Bonome regards the parasite as essentially animal in character, allied somewhat to amœba, resembling in other respects sporidium.

While it is not probable that this disease will ever become widespread in this country, the losses in Deer Lodge Valley indicate clearly that in an infected locality it may prove a most disastrous scourge to flocks, and we feel that the publication at this time of this preliminary description of the malady is warranted in order to direct the attention of veterinarians, and flock owners to the subject, that in case of future outbreaks its real nature may be recognized or suspected and reported for further study, to the end that means for its prevention and eradication may be found.

The Experiment Station desires that future outbreaks of disease among sheep, presenting symptoms identical with or closely similar to those above related, be promptly reported to the veterinarian.

630.679
M9ea

Bull. 9-12

THIRD ANNUAL RERORT

OF THE

MONTANA AGRICULTURAL EXPERIMENT STATION

◆

1896.

◆

Bozeman, Mont.,
The Avant Courier Publishing Co.,
1896.

BULLETIN NO. 9.

MONTANA
AGRICULTURAL
EXPERIMENT STATION

POTATOES.

Methods of Successful Growers.---Variety.--Test.---Depth of Planting. - - Quantity of Seed.--Time of Cutting and Treatment to Prevent Scab.

BOZEMAN, MONTANA, APRIL, 1896.

Bozeman Chronicle,
Book and Job Printers,
1896.

MONTANA AGRICULTURAL

EXPERIMENT STATION.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman.
Peter Koch, Secretary and Treasurer	Bozeman.
George Kinkel, Jr., Vice President	Manhattan.
Walter Cooper	Bozeman.
Nelson Story	Bozeman.

EXPERIMENT STATION STAFF.

S. M. Emery	Director and Horticulturist.
Luther Foster, M. S. A	Agriculturist and Botanist.
F. W. Traphagen, Ph. D, F. C. S	Chemist.
W. L. Williams, V S	Veterinarian.
A. M. Ryon, C. E	Irrigation Engineer.

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

Montana Experiment Station,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Experiment Station.

Bulletin No. 9. **April, 1896.**

POTATOES.

LUTHER FOSTER.

INTRODUCTION.

For the past two seasons special potato experiments have been in progress at this station; during the first of these, only two things were attempted, viz: variety comparison and treatment of the scab disease. Last season these two lines were largely extended and additions made in methods of seeding, quantity of seed per acre, and time and methods of cutting the seed potatoes.

The season of 1895 was below the average for conditions favorable to the best results in potato growing in the Gallatin valley. The extended cold, damp weather immediately following our planting was a severe test on the ability of the different varieties to withstand the tendency of such conditions to rot the seed, as well as a test of the best depth to plant. As will be noticed further on, the stand was very irregular, ranging from 10 to 90 per cent., only a few perfect. It will be seen that our time of planting was medium, though really as early as the ground seemed in fairly good condition. The different valleys of the state vary so greatly in conditions—time of planting, length of season, kind of soil, etc.—that what may be exactly right for some of them may not be applicable to the others. This seems especially true of the Gallatin valley, with its high elevation and short growing season. However, this much may be safely relied on—whatever varieties or methods succeed here will be successful in any other valleys of the state, but in many localities, on account of the longer, warmer summer and the especially favorable soil conditions, much more may be accomplished, as, for example, in growing for the early market. As to the extension or contraction of potato growing as a business, the farmers in the different parts of the state are best prepared to judge for themselves. In this section it does not seem probable that we can rely on the general market making a price that will warrant any production for outside shipment. However, it is not the business of the Station to determine how much to produce, but rather to find out the best methods to follow and the best kinds to grow, whether the acreage be large or small.

METHODS OF SUCCESSFUL GROWERS.

In order to give the benefit of extended experience from various portions of the state and to show what is the common practice in growing for market, the methods followed by some of the most successful producers are given below as much in detail as space will permit.

Mr. John M. Robinson, a successful farmer of the Gallatin valley, who exerts his efforts in the direction of diversified products rather than special crops, pursues the following general method in raising potatoes: In soil he prefers a sandy loam, summer fallowed six to eight inches deep, or new sod plowed either the previous June or in the spring just before planting. In either case the land must be well drained. He believes in very thorough preparation just previous to planting; it should be finely pulverized and made level. He plants by hand in rows three feet apart, and one cutting every fourteen inches in the row. The cuttings contain from one to two eyes and are covered to a depth of five or six inches. He has never been troubled by the seed rotting after planting. He practices shallow cultivation, using Robinson's Exterminator until the potatoes come up. He slightly hills them in the last cultivation, which for best results he gives just before or about the time of blooming.

If the season is dry two irrigations are given, one a few weeks before blooming and the other soon after, when the tubers are well set. In ordinary seasons one watering is sufficient, given about the time of the latter irrigation above. In no case should the ground be flooded, not even around the hill. In all his experience he has never had the quality of the crop injured by over-irrigation. In harvesting he throws them out with the ditch plow, following with the harrow after a first picking. He sells in the fall, and has seldom found the market so low that it paid to feed the crop. By changing to new locations each year he has kept his potatoes free from scab without special treatment. He grows for his principal crop the variety, State of Maine, and for early, Beauty of Hebron. Mr. Robinson uses Paris green, at the rate of two tablespoonfuls to five gallons of water, to destroy bugs, and he considers it a positive waste of time to pick the old bugs by hand when they are depositing eggs. He thinks the deep grown potatoes of best quality. On new sod, plowed in spring just before planting, he has raised 400 bushels per acre.

Director A. J. Hylton, of the State Reform School at Miles City, considers a sandy loam, plowed eight inches deep in the spring, and pulverized as deeply as plowed, best for a good yield. He plants two seed pieces of one or two eyes per hill, twenty inches apart, and covers them six inches deep. For most of the cultivation he uses a double-shovel plow, giving final hilling just before they begin to bloom, with a turning plow. All irrigating is also done before the bloom appears. Early Rose and Beauty of Hebron are the kinds grown, and these have not been affected by scab, nor has the seed rotted in the ground after planting.

Mr. W. E. Bass, of Stevensville, is very successful in growing the Early Rose on black granite soil, following a wheat crop, plowed in the spring from four to six inches deep. He plants in drills, seed pieces six inches apart, and covers to a depth of four inches. He feeds surplus to his hogs.

Mr. J. F. Borough, also of Ravalli county, says he prefers a deep sandy loam, and that sagebrush soil is next best. He believes a clover sod, plowed eight or ten inches deep in the fall, gives the best results, and this may be cropped two years in succession without danger of scab. After thoroughly pulverizing the soil and making furrows three or four inches deep, Mr. Borough plants in hills, thirty inches apart, and puts two pieces in a hill, with two eyes in each piece. In his experience, three or four inches is the best depth for covering. He uses a five-tooth cultivator, and since his potatoes are planted in hills, he cultivates both ways, and believes the ground is thus kept in better condition and more economically freed from weeds. The last cultivation is given about the time the vines are in blossom, and the cultivator teeth are set so as to throw the soil toward the rows.

When the season is dry he irrigates twice, first just after the first cultivation, when the vines are three inches high, and again about the time they are in blossom. He believes it best to sell in the fall and avoid the extra handling required for holding over winter. In following clover he is not troubled with the scab and no seed rots in the ground. This latter he believes due to his having the ground in good condition, not planting too early, and to his care in selecting smooth, even, solid potatoes for seed. He finds Early Rose the best yielder, but also grows Early Ohio and Burbank's seedling.

Mr. George L. Gordon, of Willow Creek, has been very successful in potato culture. Early Standard, Rural New Yorker, Bliss' Triumph, and Crown Jewel all do well with him. He prefers bench land, and has found it fully ten days earlier than the bottom. The crop does equally well following wheat, oats or peas. His plan is to plow as early in the spring as possible, and harrow lightly to smooth the surface, then let it stand until the first of May, when all the foul seeds will be nicely started and easily destroyed. He replows the land at planting and drops the seed pieces ten inches apart in every third furrow, a fourteen-inch plow being used. The first plowing is seven inches deep and the second only five, which leaves two inches of loose soil under the seed. In preparing the seed medium potatoes are cut into four pieces, regardless of the number of eyes. He irrigates but once, unless the season is unusually dry, and this is done about the time of blossoming. His cultivation is done with a double shovel plow, excepting just preceding irrigation, when a single shovel is used, so as to leave a good ditch for the water. He harvests with a potato fork, and sells in the fall, delivering at Butte in car lots. Scab has not found its way into his fields, but he is troubled by seed rotting in the ground.

The Rundell brothers, whose ranch is located on the Antelope, near Pony, have made a business of growing potatoes for the Butte market for a number of years. They reply as follows concerning their methods: "Any good upland soil, free from alkali or reasonably so, is suitable for a good crop. To obtain such crop with the least effort we prefer native sod, growing two crops on the same ground in succession, the second crop being by far the better. We seldom use the same ground more than two years in succession, since it seems inclined to scab, and especially so if manure is used. Of course, we cannot always have native sod, and for our methods of field culture we cannot manure. Next to the native sod we therefore prefer to follow a nitrogenous crop, such as clover, alfalfa or peas, but we find the cultivation more difficult. We usually plow in the spring eight to twelve inches deep, and think there is little difference in results between fall and spring plowing.

"In an experience of sixteen years growing for market we have tried almost every way of planting, but for the past several years have used the Aspinwall planter exclusively, and got the best results from rows three and one-half feet apart, with one seed piece dropped every fifteen inches in the row. We cut by hand and make sure that there is one good strong eye on each piece, which is all that is necessary, provided the cutting is large enough to nourish the young plant until the roots have developed sufficiently to take nourishment from the soil. The depth of planting should be determined by the time and kind of weather. If hot and dry the depth should be greater than when cold and wet; generally speaking, from two to six inches is about right.

"As to cultivation, if the ground is weedy at the time the plants begin to come up, cross-harrowing the piece will give the weeds a setback and destroy few potatoes. A two-horse cultivator is used as soon as the rows can be easily traced; this is followed in a few days by the hoe. Ten days later the cultivator is used again, the plows set deep, hilling up as much as possible. A large single-shovel plow is used to run the deep furrows for irrigation when the potatoes begin to bloom. Then all cultivation should cease. Scattering weeds that appear after this date are pulled out.

"Irrigation is by far the most intricate problem of the business. Ordinarily we give from one to three irrigations, depending on the season, kind of soil and time of planting. The grower's judgment must play an important part in this matter. The best general rule is to irrigate when the vines begin to bloom, again three weeks later, then shut the water off for the season and let the potatoes dry up.

"For harvesting we use a Hoover digger, sacking a few carloads in the field for immediate shipment; the rest are stored to be sold during the winter and spring. Scab is prevented by care in the selection of seed and by frequent change of soil. At present in our markets, Mills' Prize stands at the head of the list for general crop, with Beauty of Hebron for first early."

From Mr. F. W. Schauer, a prosperous grower at Laurel, in the Yellowstone valley, I learn that he prefers a sandy loam, with a crop of alfalfa, clover or rape plowed under in the fall, and still he has succeeded well, following corn, peas or wheat. In the latter case spring and fall plowing do equally well, but the depth should be at least six inches, and as much deeper as you can conveniently make it. He uses no fertilizer, makes the soil fine and smooth, and plants in drills three feet apart, with one piece every sixteen inches in the row. He covers four to six inches deep, and has no trouble with seed rotting except in very wet seasons. He cuts to as few eyes as possible, and leave the piece large enough to give the plant a good start. In cultivation he practices shallow stirring until the potatoes begin to set, when he hills them up and furrows for irrigation. This he gives whenever the crop needs water, without any particular attention to the period of growth. The digging is done with a fork, and the potatoes are sacked in the field. Scab is prevented by a system of rotation, changing ground each season. He grows the Ironclad, Rural New Yorker, Freeman, World's Fair and Burpee's Earliest, but considers the first three the best for all markets.

VARIETY TEST.

SOIL.

Potatoes do well on a great variety of soils, but the requisites are that it must be rich, well drained and thoroughly prepared. Growers generally agree that a rich sandy loam is best, that heavy clay should be avoided, unless it is especially prepared by plowing under clover or some other green crop to make it loose and mellow, and that low, wet land will not produce a crop of good quality. It is generally believed that potatoes of the best quality and finest flavor are produced by a light sandy loam Mr. J. F. Duggar, of the United States Department of Agriculture, said in a recent Farmers' Bulletin on the subject: "The ideal soil for this crop should be one so light as to offer no great resistance to the enlargement of the tubers, so supplied with organic matter as to be rather moist without being wet, and so rich as to furnish an unfailing supply of fertilizing ingredients."

The soil of the Station farm is by no means a model one for potatoes. Its analysis may be found in Bulletin No. 7. It would be classed as a medium clay, one on which for best results, potatoes should follow a clover crop plowed under in the fall. The land used for the variety test had, the previous season, grown a crop of barley strongly infested with wild oats.

CULTIVATION.

The ground was plowed in the fall to a depth of six inches and thoroughly worked over in the spring with an Acme pulverizer just preceding the planting. In keeping the soil loose and free from weeds, much hand labor is saved by the very thorough preparation of the seed bed and cultivation with the harrow previous to and at the time of coming up. All cultivation should be shallow, unless the ground becomes packed or weedy, when deeper working may be necessary, in order to make the soil mellow or destroy the weeds.

The variety plats were cross-harrowed when the plants were just beginning to come through the ground, and given three additional cultivations with a Planet Jr. implement by the time they were fully in bloom. In the last going over the hillers were put on and set to throw the dirt well toward the rows.

The plats as a whole received but one irrigation and that was given at a time when most of the varieties were in bloom, but by a break in the ditch running near the piece a portion of several plats was flooded two or three times, making the ground hard and lessening the growth of vines and yield of potatoes.

PLANTING.

The planting was done May 10th and 11th with an Aspinwall planter, set to drop one seed piece every thirteen inches, in rows three feet apart. The depth of planting was four inches, and the seed potatoes were cut with an Aspinwall machine.

The following tabulated statement shows the total and salable yields in pounds, the per cent. of small or unsalable, and the per cent. of stand, also the gross yield in pounds for 1894, where the same variety was grown both seasons, and the average for the two seasons.

With few exceptions all the seed potatoes for the variety test of 1894 came from the seed store of J. C. Vaughan, Chicago. The varieties added in 1895 were received from the following sources: From Henry A. Dreer, Philadelphia, Early Puritan, Lightning Express and Irish Daisy; Peter Henderson & Co., New York, Early Norther, Vanguard, Charles Downing, Snowdrop, New Ideal and Rural Blush; J. C. Vaughan, Carman, No. 1, Irish Cobbler, Pedigree, Early Rose, Dandy and Maggie Murphy; W. Atlee Burpee, Philadelphia, Great Divide, Prince Edwards Island Rose, Burpee's Superior, Burpee's Extra Early, Empire State, White Elephant and White Star; John A. Salzer Co., La Crosse, Early Wisconsin, Salzer's Earliest, Early Six-Weeks, Prize Taker, Harvest King, Early Cyclone, Fillbasket, Oregon Pearl, Quick Return and Hundredfold. Two varieties were furnished by W. W. Wylie, and one each by Clinton Wilson and John M. Robinson, of Bozeman; also one by Hon. H. W. Warner, of South Dakota.

VARIETY COMPARISON.

TABLE I.

	Yield in Lbs. per acre.		Per cent. Unsalable	Per cent. of Stand	Total yield 1894	Average yield for 1894-95
	Total.	Sal'ble				
Delaware	4,620	4,235	8.3	59.6	17,368	10,994
Leviathan	6,407	5,967	7.	74.4	10,200	8,124
Alexander's Prolific	5,637	5,170	8.3	77.	20,011	12,824
Burpee's Superior	7,342	6,545	11.	86.4		
Early Norther	6,050	5,610	7.3	77.7		
White Star	4,620	4,152	10.	51.4		
Prize Taker	5,060	4,702	7.	52.2		
Rural New Yorker No. 2	7,315	6,488	11.	59.2	12,825	10,069
Freeman	4,207	3,740	11.	65.4	13,168	8,688
New Ideal	2,722	2,610	4.	28.8		
Wilson's Choice	6,930	6,407	7.5	57.6		
White Elephant	7,892	7,067	10.5	72.4		
Arizona	6,105	5,775	5.	60.	17,621	11,863
Campbell	6,270	5,445	13.	77.	10,636	8,453
Maggie Murphy	5,445	5,253	3.5	66.2		
Summit	6,270	5,940	5.	65.	11,600	8,935
Oregon Pearl	4,070	3,740	8.	58.		
Early Polaris	3,822	3,685	3.5	49.	10,830	7,326
Wylie	7,865	7,315	7.	67.		
Early Ohio	4,647	4,235	9.	70.	8,867	6,757
Leviathan	6,985	6,545	6.3	54.7		
Thorburn	4,565	4,235	7.5	63.	13,133	8,844
American Wonder	6,462	6,077	6.	70.	19,251	12,856
Lightning Express	3,740	3,273	12.5	54.3		
Hundredfold	4,620	4,290	7.	64.6		
Crown Jewel	7,095	6,380	10.	65.8	14,747	10,921
Charles Downing	6,336	5,874	7.	80.6		
Empire State	6,116	5,676	7.5	76.		
Early Vaughan	1,848	1,540	16.6	47.7	7,252	4,550
Reed's Eighty-Six	5,104	4,532	11.	70.4	13,538	9,321
Quick Return	5,060	4,488	11.	72.7		
Six Weeks Market	2,684	2,288	14.	65.4		
Prince Edwards' Island Rose	1,980	1,848	6.6	40.4		
Warner's Blush	3,366	2,882	14.	75.		
Lee's Favorite	1,672	1,540	8.	32.5	10,621	6,147
Vanguard	7,216	6,424	11.	75.	11,292	9,254
Snowdrop	4,202	3,826	10.	54.6		
Early Telephone	3,080	2,728	11.5	43.		
Rose Seedling	3,828	3,608	6.	50.3		
Harvest King	6,996	6,754	3.5	74.6		
Irish Cobbler	5,324	5,082	4.5	73.		
Acme Seedling	3,388	3,036	10.5	64.4	6,758	5,076
Beauty of Hebron	6,622	6,116	7.5	60.	15,404	11,013

VARIETY COMPARISON. TABLE I—CONTINUED.

	Yield in Lbs. per acre.		Per cent. Unsalable	Per cent. of Stand	Total yield 1894	Average yield for 1894-95
	Total.	Sal'ble				
Burpee's Extra Early	2,816	2,552	9.3	40.		
Irish Daisy	6,072	4,972	18.	72.7		
Wylie's White	6,666	6,446	3.5	60.		
World's Fair	4,996	4,644	12.	57.6	11,884	8,440
Rural Blush	4,136	3,674	11.	70.4	9,436	6,786
Dandy	5,126	4,862	5.	60.		
Early Oxford	6,314	5,984	5.3	62.5	16,820	11,567
Great Divide	5,192	4,620	11.	76.3		
Carman No. 1	5,280	4,752	10.	77.3		

On account of the very low per cent. of stand, the weak, unhealthy growth of the vines and the small yield and poor quality of the potatoes, the following kinds were not included in the tabulated statement:

Early Puritan, Fillbasket, Red Ohio, Early Cyclone, Early Wisconsin, Salzer's Earliest, Pedigree Early Rose, Blue Victor, Snowflake, Mammoth Pearl and State of Maine.

It will be noted from the column headed per cent. of stand in the table, that the stand was very irregular and none perfect. In some instances, not included in the report, it was as low as four hills, out of a possible two hundred forty-three, and many varieties having a better stand, were weak and spindling in their growth, showing a lack of vigor throughout the season. This was especially noticeable in eastern grown seed, but in a few of the best stands the seed came from the same source. The imperfect stand was due to the seed pieces rotting during the cold, damp weather immediately following the planting. Since all varieties were planted within twenty-four hours of each other, in the same character of soil, the stand may be taken as a test of the hardiness of the different varieties, or rather their ability to withstand the cold, damp weather likely to occur here during the seeding season. In 1894 the weather conditions were more favorable, the stands better and the growth more vigorous, as the larger yield indicates.

DEPTH OF PLANTING.

The depth of planting in general practice, depends, to some extent, on the soil, time of planting and the variety. For the earliest planting, before the soil has warmed down very far, shallow covering will insure quicker growth and the seed will be less liable to rot. Two to three inches is best for the early plantings. While this depth, no doubt, gives a greater per cent. of sun burnt potatoes; the loss is more than compensated by the better stand secured and the time gained in maturity. For the main crop, four to five inches is the usual depth, but many advocate deeper planting, believing that the greater depth gives a larger yield and better quality.

It was to determine something definite in depth of planting the main crop on Gallatin Valley soil that an experiment, embracing the subject, was begun last season. The results must be regarded as merely suggestive, for it is only by the average of several years work, that reliable conclusions are reached. The experiment consisted of seven rows, each eight rods long and each planted at a different depth, varying from two to ten inches. The planting was done by hand May 18th. Beauty of Hebron, machine cut, being used for seed. The rows were three feet apart and one seed piece planted every thirteen inches in the row. The shallow plantings came up earlier, matured earlier and were more vigorous throughout the season than the deep plantings. The decline in size and vigor of vine, plainly began with the depth of five inches and increased to the deepest. The table following gives the comparative results:

TABLE II.

DEPTH OF PLANTING.

	Yield in Lbs. per acre.		Per cent. Unsalable	Per cent. Sunb'rn'd	Per cent. of Stand
	Total	Salable			
Two inches deep	8,400	5,737	20.	11.	65.5
Three inches deep	6,435	4,944	13.	10.	43.8
Four inches deep	6,314	5,355	6.	9.6	35.5
Five inches deep	3,651	3,268	10.6	.0	26.4
Six inches deep	4,643	4,073	12.2	.0	43.
Eight inches deep	2,593	2,393	5.4	.0	22.3
Ten inches deep	839	797	5.	.0	8.2

It will be seen from the table that while the stand is, in no case, good, there is, with one exception, a constant decrease in per cent. with the increase of depth. The damage from exposure differs but slightly in the two, three and four inch depths, but it entirely disappears after the five inch covering is reached. The largest per cent. of unmerchantable, reaching nearly one-third of the product, occurs in the shallowest planting. Farther experiments may materially change some of these results.

QUANTITY OF SEED.

The various methods of cutting and planting seed potatoes, followed by practical growers, indicate a wide range in the quantity of seed used per acre. By reference to the methods of some successful producers, detailed in the fore part of this bulletin, it will be seen that some advocate a much more liberal use of seed than others. Many growers, of long experience, claim that they uniformly obtain not only the larger total yield from light rather than from heavy seeding, but also the greater yield of salable potatoes. The results of Experiment Stations show that the total yield increases with the quantity of seed, but the salable increase is not in proportion to the total, nor is the increase beyond a certain quantity a profitable one, on account of the greater quantity of seed required.

In order to assist in determining what methods are best to follow in cutting and planting potatoes, a series of experiments was begun last season, in which drills planted thick and thin, were compared with hills planted with different numbers of seed pieces per hill, and whole potatoes of different sizes planted in both hills and drills, were compared with seed pieces of various kinds. The results are given in tables III and IV. The rows were all three feet apart. The seed potatoes for table III were machine cut, and those for table IV cut by hand to a definite number of eyes, the piece of tuber in each case being large enough to insure the plant a vigorous start. The variety known as World's Fair, was used for seed, being taken from the bin without special selection other than throwing out unsalable and imperfect ones. A row two rods in length was used for each method.

TABLE III.

HILLS VERSUS DRILLS.—HILLS.

	Yield in Lbs. per acre.		Per cent. Unsalable	Per cent. of Stand
	Total.	Salable		
One seed piece every $3\frac{1}{2}$ feet	5,830	5,197	10.8	100.
Two seed pieces " " "	7,040	6,187	12.	100.
Three " " " " "	8,277	7,480	9.5	88.8
Four " " " " "	11,495	9,965	12.4	100.

DRILLS.

One seed piece every 6 inches	9,825	6,985	27.4	80.3
" " " " 8 "	8,993	6,602	26.6	83.6
" " " " 10 "	12,540	9,560	15.7	74.3
" " " " 12 "	13,832	12,402	10.3	78.7
" " " " 14 "	9,707	8,360	13.8	75.
" " " " 16 "	8,525	6,765	20.6	95.8
" " " " 18 "	10,725	9,322	13.	86.3
" " " " 20 "	10,670	9,990	9.	89.4

TABLE IV.

WHOLE POTATOES VERSUS CUTTINGS.—DRILLS.

	Yield in Lbs. per acre.		Per cent. Unsalable	Per cent. of Stand
	Total.	Salable		
1 piece with one eye every 12 inches	7,920	6,600	16.6	70.
2 " " " " " " "	6,985	5,060	27.5	88.
1 " " two " " " "	11,824	10,327	12.5	90.9
2 " " " " " " "	10,615	8,277	21.5	97.
1 half potato every 12 inches	10,285	6,627	35.5	88.
2 " " " " "	10,202	4,647	54.4	88.
1 average whole potato every 12 inches	24,575	20,057	18.4	85.
2 " " " " " "	18,287	10,202	44.2	94.
1 small potato every 12 inches	9,625	6,105	36.5	88.
2 " " " " "	12,210	5,280	56.7	85.
1 medium potato every 12 inches	25,350	22,275	15.8	82.
2 " " " " "	22,440	13,944	37.8	67.
1 large potato every 12 inches	11,962	9,433	21.	82.
2 " " " " "	12,595	8,993	28.6	85.

HILLS.

1 piece with one eye every 3½ feet	6,951	6,297	9.5	100.
2 " " " " " " "	4,867	3,960	18.6	100.
1 " " two " " " "	6,160	5,445	11.6	100.
2 " " " " " " "	5,720	5,033	12.	100.
1 half potato every 3½ feet	7,150	6,930	3.	88.
2 " " " " "	11,880	9,010	15.7	100.
1 small potato every 3½ feet	10,202	9,680	5.	100.
2 " " " " "	12,595	11,385	9.6	100.
1 medium " " " "	7,205	6,765	6.	88.
2 " " " " "	8,965	7,590	15.3	100.
1 medium potato every 3½ feet	8,525	8,030	5.8	100.
2 " " " " "	9,680	8,910	8.	100.
1 large " " " "	14,713	13,867	5.6	88.
2 " " " " "	14,520	12,760	12.	100.

SEED ENDS OFF.—DRILLS.

1 small potato every 15 inches	16,115	14,355	10.9	80.
1 medium " " " "	12,375	11,055	10.6	92.
1 large " " " "	12.897	11,000	14.7	80.
1 piece with 2 eyes every 15 inches	11,510	10,037	13.	100.

HILLS.

1 small potato every 3½ feet	10,313	9,873	4.2	100.
1 medium " " " "	9,597	8,800	8.2	100.
1 large " " " "	9,240	8,140	11.7	100.
1 piece with two eyes every 3½ feet.	6,242	5,830	6.6	100.

It will be seen from the table that with a few exceptions, in the heavier seeding, the drills gave by far the greater total yields, though the per cent. of unsalable was decidedly larger. In hills, the best yield from cutting was obtained from four seed pieces, machine cut, per hill, while in drills, the greatest yield from the same source was given by one seed piece, machine cut, every twelve inches, but in both hills and drills the greatest returns came from whole potatoes, viz: in drills from one medium potato planted every twelve inches and in hills from one large potato, every three and a half feet. An average of the yields from whole potatoes of the different sizes, computed in pounds per acre, gave the following results: Average of four plats of small potatoes, 11,158; six of medium, 18,143 and four of large, 13,442.

It is the general belief that degeneration will result from the continuous use of small potatoes for seed. A few farmers, who have made a practice of selecting the largest of the unsalable potatoes and planting them whole, claim, after a number of year's experience, that no deterioration results from such practice. From the results of the different Stations that have made experiments in this line, it is found that they very generally agree that small tubers, planted whole, may be used for seed for at least a few years without materially reducing the yield or quality of the crop. Experiments have not been in progress long enough to determine if degeneration will finally result trom their continued use. Until something more definite and conclusive is determined, it seems best, except in special cases, to continue the practice of carefully selecting seed potatoes.

The following, from Farmers' Bulletin No. 35, issued by the U. S. Department of Agriculture, gives a very accurate estimate of the number of bushels required per acre by the different methods commonly followed in cutting and planting: "A bushel of potatoes (60 pounds) may contain 240 quarter-pound tubers. When the seed pieces are planted a foot apart in 3-foot rows, an acre requires 14,520 sets. When tubers, averaging four ounces, are employed, an acre requires, at these distances, 60 bushels for planting whole potatoes, 30 bushels when halves are used and 15 bushels when quarters are planted. In a number of tests the amount of seed cut to 2 eyes, spaced 1 by 3 feet, averaged 13 bushels per acre, the usual range being from 10 to 14 bushels. In 18 experiments with many varieties, the average amount of seed cut to single eyes was at these distances, 6.3 bushels per acre, the usual range being from 5 to 7 bushels, though the varieties with large tubers bearing few eyes required considerably more seed.

"Results which follow in these pages suggest that it is generally advisable to plant at least 15 to 30 bushels per acre."

The following concerning the effects of size of seed pieces on the yield of crop is also taken from the same Bulletin. As indicated above, the facts given are deduced from the average results of numerous State Experiment Stations.

EFFECT ON TOTAL YIELD.

"In making up the averages below it was found practicable to use the results of 19 tests of single eyes *vs.* 2-eye pieces, 4 tests of 2-eye cuttings *vs.* quarters, 17 comparisons of quarters and halves, and 44 tests of halves *vs.* whole potatoes. The results of other experiments less completely reported were used for the purpose of corroboration.

The following table shows the average results of these tests, including potatoes of all sizes:"

AVERAGE DIFFERENCES PER ACRE IN TOTAL YIELDS FROM DIFFERENT SEED PIECES.

	Bushels.	Per cent.
Excess from use of—		
2-eye pieces over 1-eye pieces	26	21
Quarters over 2 eye pieces	15	16
Halves over quarters	24	18
Whole tubers over halves	31	18

"If we compare all the total yields with the total yield produced by single eyes, we have an increase of 21 per cent. for 2-eye pieces, 41 per cent., for quarters, 67 per cent., for halves, and 96 per cent. for entire tubers. The total yield resulting from planting whole potatoes, is practically double that obtained by planting single eyes."

EFFECT ON GROSS SALABLE YIELD.

"By averaging the results of the experiments referred to above, we find that the actual increase in the potatoes of salable size, due to using larger seed pieces, was as follows:"

AVERAGE DIFFERENCES PER ACRE IN GROSS SALABLE YIELDS FROM DIFFERENT SEED PIECES.

	Bushels.	Per cent.
Excess from use of—		
2-eye pieces over 1-eye pieces	23	21
Quarters over 2-eye pieces	10	15
Halves over quarters	15	15
Whole tubers over halves	14	10

Every increase in the size of the seed pieces was followed by an increased gross salable yield.

The true test of profit is the market value of the crop produced, less the cost of seed planted.

The following table shows the actual average results for the net salable yield; that is, the crop after deducting the small potatoes and the seed used:

AVERAGE DIFFERENCES PER ACRE IN NET SALABLE YIELD FROM DIFFERENT SEED PIECES.

	Bushels.	Per cent.
Excess from use of—		
2-eye pieces over 1-eye pieces	15.0	14
Quarters over 2-eye pieces	7.0	15
Halves over quarters	5.0	6
Halves over whole tubers	8.5	8

The amount of the net salable crop rose with the increase in the size of the cutting employed, but when the whole potato was planted, the figures declined, on account of the large amount of seed potatoes which had to be deducted. The above figures indicate a very slight advantage in planting halves rather than quarters when the price of seed and of crop produced are the same. As a matter of fact, spring prices are usually somewhat higher than fall prices. A higher price for seed potatoes may make it profitable to plant smaller pieces (as for example, quarters) than would be economical where seed and crop command the same price per bushel."

SEED POTATOES CUT DIFFERENT LENGTHS OF TIME BEFORE PLANTING.

There is an idea prevalent that seed potatoes cut several days before planting, give better results than freshly cut pieces. The few experiments tried by other Stations, indicate, on the average, no special difference in yield and quality between planting newly cut seed and that cut from five to eight days before planting. Much seems to depend on the soil, climate, kind of season and place of storing cut seed. No great disadvantage would likely result from planting slightly wilted seed in soil that is kept well moistened for some time after planting, but a very different result might reasonably be looked for in planting wilted seed in a slightly moist soil that is likely to become drier during the germinating period.

If frequent rains come for a few weeks after planting, no loss is likely to result from the slightly wilted seed. Seed pieces stored in an open shed or room above ground will wilt badly, while those stored in a good root cellar will scarcely show any signs of wilting.

From the following table, giving the results of last season's experiment, it will be seen that the stand and yield show a strongly marked difference in favor of the freshly cut seed. The variety of potatoes used was Beauty of Hebron, depth of planting four inches, and the soil the same as that used for the experiment in treatment of scab and the quantity of seed test. The seed pieces were placed in a seamless sack and stored in a rather open log building, the quantity being too small for damage from heating and still large enough to prevent rapid drying. The tubers had been subjected to the usual corrosive sublimate treatment for scab before cutting.

TABLE V.

SEED CUT DIFFERENT LENGTHS OF TIME BEFORE PLANTING.

	Yield—Lbs. per acre	Yield. Salable	Small, Per cent.	Stand, per cent.
Cut May 17, planted May 22	3,513	3,493	6.	34.6
Cut and planted May 22	8,167	7,315	10.4	92.3
Cut May 17, planted May 27	2,125	1,760	18.	22.7
Cut and planted May 27	8,167	6,215	23.9	80.8

POTATO SCAB.

Although it had already been well established, first by Prof. Bolley, of the North Dakota Station and afterwards by others, that corrosive sublimate is almost a sure preventive of this disease, an experiment was made last season to determine the effect of other chemical compounds on the disease, and to find, if possible, either with a stronger solution of the corrosive sublimate or with other compounds, a treatment that would effect the same purpose in a shorter time. All the compounds used, in some strength of solution, were effective in reducing the scab, but none except the corrosive sublimate gave a product entirely free from the disease, and this, in no case, in less time than the treatment of one hour. Neither the strong solutions nor long periods of treatment seemed to injure the germinating power of the tubers, in fact the most perfect plats in stand and vigor of vines in all the experiments were in the scabby division. Out of the 39 plats, all were perfect in stand but three. The seed used was of the variety, Blue Victor, and the tubers were entirely covered with the pits, in that respect they were in excellent condition for the experiment.

The table "slightly scabbed" includes all tubers that showed only slight effects of the disease, not enough to be especially noticeable to the ordinary observer or to detract from their market value.

All degrees of scabbiness beyond this were included under "badly scabbed" but a tuber was seldom found as completely covered as was the seed potatoes.

TABLE VI.

RESULTS OF TREATMENT FOR POTATO SCAB.—ZINC CHLORIDE.

	Yield—Lbs. per acre	Per cent. free from Scab	Per cent. slightly Scabb'd	Per cent. badly Scabbed
50 grams to 1 quart water, dipped	12,155	60.	30.2	9.8
" " " " 30 minutes	7,885	93.5	6.5	
" " 2 " " "	11,350	51.4	48.6	
" " 3 " " 60 "	13,072	85.3	14.7	
" " 5 " " 90 "	6,588	56.4	43.6	
Average of 4 plats not treated	7,136	20.1	49.7	30.3
ZINC SULPHATE.				
50 grams to 1 quart water, dipped	7,470	44.4	55.6	
" " " " 30 minutes	11,257	83.9	16.1	
" " 2 " " "	10,012	66.3	33.7	
" " 3 " " 60 "	9,545	59.2	40.8	
" " 5 " " 90 "	7,522	20.7	79.3	
Average of 3 plats not treated	6,623	18.8	49.1	32.1
POTASSIUM PERMANGANATE.				
10 grams to 1 quart water, dipped	11,153	37.8	41.5	20.7
" " " " 30 minutes	13,433	40.	60.	
" " 2 " " "	8,664	39.5	60.5	
" " 3 " " 60 "	10,480	47.	53.	
" " 5 " " 90 "	7,782	84.	16.	
1 plat without treatment	9,078	24.	51.4	24.6

RESULTS OF TREATMENT FOR POTATO SCAB. TABLE VI.—CONTINUED.

POTASSIUM BICARBONATE.

	Yield—Lbs. per acre	Per cent. free from Scab	Per cent. slightly Scabb'd	Per cent. badly Scabbed
50 grams to 1 quart water, dipped	3,996	53.3	46.7	
“ “ “ “ 30 minutes	8,976	51.5	48.5	
“ “ 2 “ “ “	7,055	38.2	81.8	
“ “ 3 “ “ 60 “	7,730	37.6	82.4	
“ “ 5 “ “ 90 “	8,430	57.7	42.3	
Average of 4 plats without treatment	7,336	20.1	49.7	30.3

POTASSIUM SULPHIDE.

50 grams to 1 quart water, dipped	6,120	27.1	72.9	*
“ “ “ “ 30 minutes	6,173	36.1	63.9	†
“ “ 2 “ “ “	7,211	66.2	33.8	
“ “ 3 “ “ 60 “	8,145	61.2	38.8	
“ “ 5 “ “ 90 “	8,715	26.2	37.5	36.3
Average of 3 plats without treatment	6,623	18.8	49.1	32.1

*Two tubers. †One tuber.

CORROSIVE SUBLIMATE.

1 ounce in 1 quart water, dipped	4,330	93.5	6.5	
“ “ “ 15 minutes	4,252	45.1	54.9	
“ 2 “ “ 30 “	3,165	86.9	13.1	
“ 3 “ “ 30 “	4,818	85.4	14.6	
“ 6 “ “ 60 “	2,802	100.		
“ 12 “ “ 90 “	3,217	90.3	9.7	
“ 24 “ “ 37 hours	4,815	96.8	3.2	
“ 48 “ “ 37 “	3,788	100.		

[The methods of the various potato growers herein quoted are given for what they are worth, and without the endorsement of the Station. The success achieved by them in potato culture renders their judgment valuable to us.]

BULLETIN NO. 10.

MONTANA AGRICULTURAL EXPERIMENT STATION

SMALL GRAINS.

...WHEAT, OATS AND BARLEY....

Methods of Soil Preparation and Seeding in General Practice.--Quantity of Seed per Acre.--Variety Comparisons. --Methods of Preventing Smuts.

BOZEMAN, MONTANA, JUNE, 1896.

Bozeman Chronicle,
Book and Job Printers,
1896.

MONTANA AGRICULTURAL

EXPERIMENT STATION.

EXECUTIVE BOARD.

LESTER S. WILLSON, President................................Bozeman.
PETER KOCH, Secretary and Treasurer..................Bozeman.
GEORGE KINKEL, JR., Vice President...................Manhattan.
WALTER COOPER..Bozeman.
NELSON STORY...Bozeman.

EXPERIMENT STATION STAFF.

S. M. EMERY.............................Director and Horticulturist.
LUTHER FOSTER, M. S. A...........Agriculturist and Botanist.
F. W. TRAPHAGEN, Ph. D, F. C. S...........................Chemist.
W. L. WILLIAMS, V S.......................................Veterinarian.
A. M. RYON, C. E..................................Irrigation Engineer.

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

MONTANA EXPERIMENT STATION,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Experiment Station.

Bulletin No. 10. June, 1896.

SMALL GRAINS.

WHEAT, OATS AND BARLEY.

LUTHER FOSTER.

METHODS IN COMMON PRACTICE.--SUMMER FALLOW.

The method generally followed by the farmers of the Gallatin valley is to grow the small grain crop, whether wheat, oats or barley, on summer fallow. For best results in soil conditions and in freeing from weeds, the plowing is done during the month of June or early part of July, before the first weed crop has reached maturity. Later, when the second crop of weeds has fairly started, the fallow is cultivated with a disk, weed exterminator or other implement that will most effectually destroy the foul stuff that has come up. Not infrequently a second cultivation is necessary.

A failure to prevent the soil from maturing a crop of weeds during the season, will, in a measure, destroy the benefits that should accrue from the year of rest. The fallow is not irrigated during the season of its non-production, but the exposure to the action of the elements, together with the cleansing given by the thorough cultivation, puts it into fine mechanical condition for the next year's crop.

A well cultivated crop of roots or potatoes leaves the soil in an almost equally good condition. Next to these in preparing for a grain crop, where the land is cropped every year, come the field pea; but the acreage that can be profitably covered by these crops is comparatively small. Until more is undertaken in stock-feeding and dairy husbandry, requiring a larger acreage of clover, alfalfa or other forage crops, the present method of cropping the soil only in alternate years will doubtless be continued, as the most successful and economical management for small grain production.

PREPARATION OF THE SEED-BED.

In the spring, just before seeding, a careful double harrowing will thoroughly pulverize the surface a few inches deep. Some prefer the disk, especially in soil that has packed too much to be easily worked into condition with the harrow. The final operation before seeding is leveling. This evens up the surface by rubbing down the high points, filling in the low places, and crushing clods that remain after the harrowing.

SEEDING.

For this a drill is usually preferred. The custom is not to follow with the harrow or leveler where the soil is well pulverized, but to leave the drill furrows, because of the aid they give in distributing the water during irrigation.

The above general plan is that followed by those who depend on irrigation. A somewhat different method is pursued with wheat in bench land or foothill localities where irrigating is not practicable. Here, while the plowing is done as above, the preparation for the seed and the planting are done during the fall, not infrequently as early as August. In practice, the time of seeding varies from this early, until quite late in the fall, depending on the kind of wheat to be sown—the winter varieties being sown early and the spring varieties late. As will be seen further on, the results of a single season's experiments in sowing spring wheat in the fall strongly favor the late sowing, from the 28th of October to the 19th of November.

In preparing the soil, if it is plowed deep or plowed to a moderate depth, six inches, and then loosened five or six inches beneath this. as in subsoiling, it would aid greatly in retaining sufficient moisture to mature the crop where irrigation is not practicable. It would also aid in irrigated fields by making it possible to defer irrigation until the grain is larger and aid in holding the moisture after it is given, so that more than one irrigation would seldom be necessary.

In the matter of loosening the subsoil to a considerable depth without bringing it to the surface, the new disk plow called "The Secretary" greatly lessens the expense and difficulties of former methods by doing the work of turning the surface and stirring the subsoil at one operation, with but little more draft than the ordinary sulky plow.

In a deep, mellow seed-bed the moisture will rise from a much greater depth to supply the needs of the plant, as well as permit the roots to extend themselves freely to a greater depth in search of moisture. In order that the constituents of the soil may be brought into the proper condition for the nourishment of the plant, the soil must be finely pulverized. The more perfect its mechanical condition the more ready prepared food is there for the plant to appropriate. Hence, too great care cannot be taken in plowing the ground and preparing the seed-bed. A little extra work here may add greatly to the yield of the crop.

The selection and cleaning of the seed is of almost equal importance. Grain that has been harvested before fully ripe, or that which has been wet, moulded or heated in the bin, also that damaged by frost, should not be selected for seed. Many farmers believe that grain grown on new soil makes the best seed because there is more likely to be a full supply of all the elements of plant food in the virgin soil than any other. The plant may therefore fully develop, not being stinted in any element, and the grain have the most perfect and natural proportions in its composition, thus making the vitality stronger and the growth of the plant more vigorous.

Thorough cleaning prevents the possibility of adding any foul stuff to the farm, and rejects any small, cracked and immature kernels. It also lessens the quantity of seed required per acre.

QUANTITY OF SEED.

In practice there is much diversity in the quantity of seed per acre believed to give the best results. The kind of soil, the condition of the seed-bed, the method of seeding, the quality of the seed and the season, have much to do with the quantity required for the largest yield. A rich, mellow soil, insuring every plant a strong growth, and choice, well-cleaned seed, planted with a drill, will require a less quantity of seed than the opposite conditions. That soil which insures most nearly the covering and germination of every kernel and furnishes plenty of food for the full development of the plant will require the smallest quantity of seed.

Experiments in this line are valuable only when the conditions are the same as those of a majority of the farmers. In the experiment of 1895 all the ground had produced a crop the previous season except a narrow strip running across the oat plats, that had served as a plat alley, and had been several times cultivated to keep it clean. The strip showed markedly the advantage of the season's rest. The dimensions of the plats were one by eight rods, and all were sown in duplicate. The general conditions were no better than those of the average farmer. The planting was done with a drill. For the wheat plats the quantity of seed varied from two to twelve pecks per acre; for the oats, from four to sixteen pecks, and for the barley, from two to fourteen pecks.

The quantity of seed was clearly shown by the appearance of the plats. The thin seeding in all cases gave strong, vigorous growth, with large, stiff straw, bearing large heads, well filled with large, plump kernels. These gradually dwindled to very short, fine straw, with short, slender heads in the thickest seedings.

Judging from a careful study of the plants, too little seed was used on the thinnest seedings and entirely too much on the thickest. The fine straw of the thick seeding stood up fully as well as the stronger stiffer-looking straw of the thinly-seeded plats. While there was a decided increase in the number of dwarf-heads and in the fineness of the straw with the greater quantity of seed, after reaching a certain limit there was a marked decrease in the stooling. In the wheat and barley this decrease was well marked after reaching six pecks per acre, and in oats after eight pecks. The thickly seeded plats were a few days earlier in ripening.

The following are the average yields per acre for the various quantities of seed:

WHEAT.

Two pecks per acre	19.	Bushels
Three " " "	21.1	"
Four " " "	22.3	"
Six " " "	21.7	"
Eight " " "	23.7	"
Ten " " "	22.8	"
Twelve " " "	22.7	"

BARLEY.

Two pecks per acre	32.	Bushels
Four " " "	32.4	"
Six " " "	35.1	"
Eight " " "	30.8	"
Ten " " "	29.7	"
Twelve " " "	31.7	"
Fourteen " "	25.5	"

OATS.

Four pecks per acre	52.5	Bushels
Six " " "	53.8	"
Eight " " "	53.	"
Ten " " "	58.5	"
Twelve " " "	55.7	"
Fourteen " "	54.	"
Sixteen " "	52.7	"

VARIETY TESTS.—WHEAT.

The variety comparison of wheat was a continuation of the work of 1894, the number of varieties being diminished by the rejection of several duplicates and some that were badly mixed. The first eighty-two kinds were seeded April 25th, 26th and 27th, the rest May 1st.

The plats for all the small grain variety comparisons contained six rows each, fourteen inches apart, and eight rods long. During the month of June they were twice cultivated with a hand implement, and once weeded. All seed was treated to prevent smut, and very little appeared in any of the varieties. The plats were all irrigated twice, July 18th, and August 1st. In addition to this, plats Nos. 1 to 8 inclusive were thoroughly soaked a few times by overflow from other portions of the field. The table following shows the time required for maturity, the yields for 1894 and 1895, and the average of the two seasons:

TABLE I.

Number	Wheat Varieties.	No. of days to mature	Yield per acre 1895	Yield per acre 1894	Average yield
1	Glyndon, No. 748	140	27.7	41.	34.4
2	" " 669	140	33 3	48.8	41.
3	Velvet Chaff	135	21.4		
4	Glyndon, No. 657	140	26.6	22.	24.3
5	" " 715	140	21.8	39.2	30.5
6	" " 636	135	20.6	38.5	29.5
7	" " 794	135	15.3	35.4	25.3
8	" " 696	140	29.6	33.	31.3
9	" " 768	140	19.9	36.7	28.3
10	" " 761	140	20.	44.	32.
11	" " 750	140	23.3	66.	44.7
12	" " 775	140	22.5	42.2	32.3
13	" " 676	135	19.6	34.6	27.1
14	" " 667	140	26.6		
15	" " 302	135	27.	41.9	34.5
16	" " 675	135	26.8	33.5	30.2
17	" " 697	140	27.	40.6	33.8
18	" " 773	140	25.5	49.5	37.5
19	" " 650	140	18.2	34.	26.1
20	" " 852	140	20.8	41.2	31.
21	" " 692	140	24.1	39.8	31.9
22	" " 774	135	17.	35.5	26.3
23	" " 744	139	19.8	45.2	32.5
24	" " 691	134	20.8	47.9	34.2
25	" " 681	138	28.	36.	32.

TABLE I.—CONTINUED.

Number	WHEAT VARIETIES.	No. of days to mature	Yield per acre 1895	Yield per acre 1894	Average yield
26	" " 447	138	19.2		
27	" " 818	138	23.7	33.8	28.8
28	" " 113	138	23.1	43.9	33.5
29	" " 638	138	22.9	33.6	28.3
30	" " 815	138	24.7	41.7	33.2
31	" " 673	138	23.9	40.5	32.2
32	" " 135	138	21.5	41.3	31.4
33	" " 619	134	31.7	40.6	36.2
34	" " 694	138	30.1	32.1	31.1
35	" " 711	138	20.3	42.5	31.4
36	**Glyndon, S. D**	133	19.4	52.6	36.
37	**Glyndon, No.** 670	133	22.5	44.	33.3
38	" " 661	138	20.4		
39	" " 963	138	21.9	38.	29.9
40	" " 758	138	19.6		
41	**French Imperial**	133	24.5	37.5	31.
42	**Bolton's Bluestem**	138	20.8	35.8	28.3
43	**Sutherlin, No. 1**	133	20.8	82.5	51.6
44	**Bluestem**	138	22.7	36.8	29.8
45	**White Chaff**	133	19.8	39.9	29.9
46	**Saskatchewan Fife**	138	19.9	41.3	30.6
47	**Blount's Hybrid, No. 17**	136	20.4	33.6	27.
48	**White Fife**	138	23.5	41.5	32.5
49	**Hayne's Bluestem**	133	20.6	38.2	29.4
50	**Silver Fife**	138	23.1	39.8	31.4
51	**Russian**	127	13.3	45.8	29.5
52	**White Russian**	133	20.6	53.2	36.9
53	**Power's Fife**	138	20.9	37.5	29.2
54	**McKissick's Fife**	138	21.2	49.4	35.3
55	**Junket**	138	22.9	41.9	32.4
56	**California Fife**	138	24.7	53.6	39.1
57	**Anglo-Canadian**	138	19.8	39.2	29.5
58	**Kubanka**	138	16.2	40.9	28.6
59	**Snowball**	138	22.7	42.6	32.2
60	**Sutherlin, No. 2**	132	20.6	44.	32.3
61	**Ladoga**	132	14.9	63.3	39.1
62	**China Tea**	132	16.7	31.2	23.9
63	**Wellman's Fife**	138	16.4	35.4	25.9
64	**Colorado**	131	7.4	32.4	19.9
65	**Pringle's Champlain**	133	20.	50.9	35.4
66	**Club**	132	18.	33.6	25.8
67	**Summer Cob**	138	23.3	48.7	36.
68	**Rio Grande**	138	21.8	42.5	32.2
69	**Bedford's Hungarian**	138	19.2	46.4	32.8
70	**Old Red River**	137	20.4	36.6	28.5
71	**Eureka**	137	27.4	45.2	36.3

TABLE I.—CONTINUED.

Number……	WHEAT VARIETIES.	No. of days to mature…	Yield per acre 1895……	Yield per acre 1894……	Average yield.
72	Hungarian Mountain	137	21.4	25.9	23.6
73	Assinnaboine Fife	135	24.7	63.3	44.
74	Wild Goose	137	26.5	33.7	30.1
75	Golden Drop	137	20.8	39.	29.9
77	Warner	137	21.8	46.4	34.1
78	Champlain	135	24.7	44.7	34.7
79	Assinnaboine Fife	138	26.8	47.	36.9
80	Red Fern	138	31.2	44.8	38.
81	Red Fife	138	20.4	59.1	39.8
82	Wellman's Fife	138	29.2	35.4	32.3
83	Glyndon, No. 339	132	19.2		
84	Blount's Hybrid, No. 15	135	20.9	45.	32.9
85	Medium Fife	135	20.7		
86	Glyndon, No. 668	135	21.1	36.6	28.8

TABLE II.

Analysis of Wheat Samples Submitted February 8, 1896.—F. W. Traphagen, Chemist.

NAME.	Number....	Per ct. moisture.......	Per cent. nitrogen....	Per ct. crude protein....
Anglo-Canadian	57	13.55	1.86	11.63
White Russian	52	12.18	1.82	11.38
Bolton's Bluestem	42	11.85	1.88	11.75
Glyndon, 715	5	12.28	1.91	11.94
Junket	55	12.06	1.78	11.13
Sutherlin, No. 2	60	14.80	1.64	10.25
Hungarian Mountain	72	15.22	1.70	10.63
Ladoga	61	13.82	1.99	12.44
Saskatchewan Fife	46	11.55	2.02	12.63
McKissick's Fife	54	11.46	1.99	12.44
Power's Fife	53	10.75	2.03	12.68
Sutherlin, No. 1	43	12.07	1.57	9.81
China Tea	62	13.10	1.85	11.57
Golden Drop	75	12.82	1.91	11.94
Red Fife	81	13.19	1.94	12.03
Hayne's Bluestem	49	12.29	1.92	11.99
Blount's Hybrid, No. 15	84	13.01	1.79	11.19
Champlain	78	13.07	1.88	11.75
Pringle's Champlain	65	12.06	1.89	11.81
Bedford's Hungarian	69	13.50	1.88	11.75
Snowball	59	12.38	1.87	11.69
White Chaff	45	12.04	1.73	10.81
Russian	51	11 73	1.88	11.75
Wellman's Fife	63	13.35	1.83	11.44
Blount's Hybrid, No. 17	47	11.68	1.93	12.05
Colorado	64	13.48	1.84	11.50
White Fife	48	11.83	1.85	11.56
Assinaboine Fife	73	13.90	1.72	10.75
Kubanka	58	12.05	1.98	12.38

LADOGA WHEAT.

The Ladoga wheat has recently attracted considerable attention in the Gallatin Valley because of its earliness, its uniformly large yield, and its tendency to retain the qualities of hard wheat under irrigation. It was introduced into this valley in 1891. Dr. Traphagen has made numerous analyses of it, both from the Station plats and the general field crops in the valley. The average analysis of that grown at the Station the past two seasons gives nearly 12.5 per cent of crude protein, which is only equaled by a very few of the large number of varieties under experimentation. Last season, after being twice irrigated, it was one of the few that stood above 12 per cent. in crude protein.

The Canadian government introduced this variety of wheat and distributed it among its farmers nine years ago. Prof. Wm. Saunders, who superintended the work of distribution, has the following to say of it:

"The object sought in its introduction was to obtain a hard wheat of good quality, which would ripen early enough to escape the autumn frosts, which sometimes injure the crops in some parts of the northwest of Canada. This wheat was selected by a seed dealer in Riga, who had made a special study of the cereals of northern Russia. It was grown in latitude 60 deg., near Lake Ladoga, north of St. Petersburg, and is known under the name of Ladoga. The locality referred to is by latitude 840 miles north of the city of Ottawa, 600 miles north of Winnipeg, and north of the northern boundary of Lake Athabaska, in the Peace river country. The Ladoga wheat is said to be highly esteemed in those parts of Russia where it is grown, and is in favor as an early ripening sort. The first consignment was brought to Canada in the spring of 1887, when 667 sample bags were distributed for test, from which 275 returns were received, and from these reports the average period of ripening was estimated from ten to fifteen days earlier than Red Fife, a gain in time of maturing which would, if maintained, materially lessen the risk of injury from frost. In the spring of 1888 a second distribution of this wheat was made, from which 301 reports have been received. These place the period of ripening, taking the entire Dominion, at ten days earlier than the Red Fife."*

OATS AND BARLEY.

The oat and barley plats were all planted the last three days of April, the seed being dipped in a solution of blue vitriol, two pounds to five gallons of water, to prevent smut. As a result of this treatment not a single smutted head was found in any of the barley plats, and only an occasional one in a few varieties of oats. The plats received the same weeding and cultivation as the wheat, but were irrigated only once, July 12th to 15th.

Among the barleys, the six-rowed type, commonly known as Manshury, is also given the names, "The King" and "Imperial" by different seedsmen. The two-rowed variety, frequently called "Duck-Bill," appears in our experiment under the following names: "Chevalier," "Duck-bill," "Kumma Kulla," "Moosenoy," and "Highland Chief."

The tabulated statement shows in both oats and barley the number of days required to mature, and the yield in bushels per acre. It also shows the yield for 1894, and the average of the two seasons where the same variety was grown both years.

---

* [The foregoing tables show the average ripening period of eighty-six tested sorts of wheat to have been 135 days, or two days more than Ladoga.

The average yield of eighty-six tested sorts of wheat in 1895 was 21.9 bushels per acre, while that of Ladoga was 14.9 bushels per acre.

The average protein content of twenty-nine sorts of wheat analyzed in 1895 was 11.59 per cent., while that of Ladoga was 12.44 per cent., or .85 of one per cent. more than the average; while three other sorts equaled or exceeded Ladoga in protein. THE DIRECTOR.]

TABLE III.

Number	OAT VARIETIES.	No. of days to mature	Yield per acre 1894	Yield per acre 1895	Average yield.
1	Black Tartarian	136	51.3		
2	Giant Yellow	157	51.8	79.2	65.5
3	Salzer's Welcome	136	67.9	73.7	70.8
4	Lost Stake	136	68.3	74 5	71.4
5	White Russian	136	69.8		
6	Black Prolific	136	60.2	74.9	67.5
7	White Swede	128	57.3	96.3	76.8
8	Early Everett	128	59.9	105.4	82.6
9	Golden Giant	157	47.4	89.	68.2
10	American White	113	50.3	77.3	63.8
11	Bland White	121	56.6	82.5	69.5
12	White Bonanza	121	61.7	79.9	70.8
13	Yellow Giant	121	61.3	82.8	72.
14	Black Prolific	136	52.5	74.9	63.7
15	White Bonanza	128	68.7	79.9	74.3
16	Race Horse	112	47.7	88.4	68.1
17	Squarehead	136	59.1		
18	Nameless Beauty	107	37.8		
20	American Beauty	131	60.6	70.7	65.6
21	Egyptian	136	65.	103.	84.
22	Prize Prolific	128	65.7		
23	Prize Cluster	136	65.7	109.1	87.4
24	Scotch	112	43.7		
25	Canadian White	132	54.3	105.4	79.8
26	Black Beauty	127	51.8	69.3	60.5
27	Bavarian	132	53.6	91.5	72.5
28	Wide Awake	132	49.6	117.	83.3
29	Mogheda	132	40.4	84.1	62.3
31	Great Northern	135	60.6		
33	Lincoln	132	56 9	104.8	80.8
34	White Schonen	132	48.1	83.3	65.7
35	Black Russian	135	67.2	84.1	75.6
36	White Maine	130	57.		
37	White Wonder	127	47.7	72.9	64.9
39	American Best	130	56.2		
40	Great Western	130	61.4	88.3	74.8
41	American Banner	132	58.4	84.1	71.3
42	Siberian	132	49.6	100.5	75.
43	New Danish	135	54.	50.1	52.
44	Badger Queen	112	36.4	64.8	50.6
45	Improved American	130	52.7	46.9	49.8
46	Archangel	130	61.	92.8	76 9
47	Tartarian	135	59.1	85.3	72.2
48	Race Horse	135	54.7	88.4	71.5
49	Jeanette	135	51.	103.1	77.
50	Henderson's Clydesdale	135	42.8		

TABLE IV.

Number	BARLEY VARIETIES.	No. of days to mature	Yield per acre 1894	Yield per acre 1895	Average yield.
1	Flannery	119	28.6		
2	The King	112	35.2	30.2	32.7
3	Imperial	112	31.6	50.2	40.9
4	Manshury	112	26.	59.1	42.5
5	Salzer's Manshury	112	33.5	48.7	41.1
6	Chevalier	125	26.	43.3	34.6
7	Duck-Bill	128	24.7	72.9	48.8
8	Manshury	105	30.	44.4	37.2
9	Success	98	12.3		
10	Manshury	109	34.8	59.1	46.9
11	Kuma Kulla	129	20.	46.4	33.2
12	Manhattan	129	44.8	68.7	56.7
13	St. Paul	109	14.6	43.1	28.8
14	Moosenoy	129	24.5	58.1	41.3
15	California Prolific	128	34.4		
16	Goldthorpe	128	44.6		
18	Highland Chief	128	27.	53.6	40.3
19	Black Hulless	104	23.5	71.5	47.5
20	New Zealand	128	28.2	55.7	41.9
21	Improved Cheyenne	129	33.1	48.1	40.6
22	Manshury	110	33.5	44.4	38.9
23	Highland Scotch	127	41.6	55.	48.3
24	New Zealand	133	36.	55.7	45.8
25	Champlain of Vermont	116	31.1	41.2	36.1
27	Carter's No. 2	127	46.3	53.4	49.8

SPRING WHEAT SOWN IN THE FALL.

To determine the practicability of sowing spring wheat in the fall and also the time to sow for best results, fifteen sowings of a variety known as Yellowstone Fife were made at different intervals during the fall of 1894, the results of which have proven of much interest, since only the later sowings passed the winter successfully and produced a crop.

Beginning the 9th of August, a small plat was sown each week until the ground was frozen and winter began, November 19th. The early seedings made a nice growth and were in good condition when the winter set in, but the later sowings were just coming up. The early plantings almost wholly killed out, the intermediate only partially, and the latest showed no damage from the winter killing, the stand being almost perfect. These plats were twice irrigated and kept free from weeds. The first six plats, sown from August 9th to September 14th, inclusive, gave an average yield of 3.3 bushels per acre. The next five plats, seeded from September 21st to October 19th, inclusive, yielded an average of 12.7 bushels per acre. The average yield of the four plats, sown October 26th and November 3d, 10th and 19th, respectively, produced at the rate of 38.5 bushels per acre.

These results cannot be taken as conclusive, but only as indicating what may be expected under like conditions. Our winters vary greatly in the amount of snowfall and the length of time it remains on the ground. The spring also varies much as to favorable or unfavorable conditions for winter wheat, so it will be necessary to continue the experiment a number of years to get an average reliable result.

PREVENTION OF SMUTS.

In this line of work an experiment was undertaken to find the most efficient and practical method of preventing the smuts of wheat, oats and barley. In all cases the seed selected was known to be badly infected with smut. The plats were uniform in soil, preparation, previous crop, and other conditions, so that whatever variation occurred in the per cent. of smut could be properly attributed to the kind of treatment given the seed.

WHEAT SMUT.

Only two methods of prevention were tried with wheat, viz.: The hot water and the bluestone (copper sulphate).

In the hot water treatment two vessels were used, the water in the one ranging from eight to ten degrees lower than the other. The grain was kept in the one of lower temperature until heated to as high a degree as the water would bring it, and then it was dipped into the other for the desired length of time. The table following shows the degree of heat in the treatment to vary from 120 deg. to

140 deg. Fah., and the time of immersion from simply dipping to fifteen minutes' soaking. Thermometers were kept in both vessels of water and the temperature made constant by the addition of hot or cold water as required.

The wheat was not cooled by dipping in cold water after the immersion, except in one instance, plat No. 17.

In the bluestone (copper sulphate) method the strength of the solution and the time the grain remained in the solution were the principal considerations. The table shows the kind of treatment and its result in per cent. of smut.

TABLE V.

Treatment of Seed Wheat for Smut.

No. plat.	TREATMENT.	Per ct. smutty heads.
	HOT WATER.	
1	Untreated	1.8
2	Immersed 15 minutes in water at temperature of 128 deg. F.	.18
3	" 12 " " " 130 "	.22
4	" 10 " " " 132 "	none
5	" 8 " " " 133 "	.23
6	" 6 " " " 134 "	.09
7	" 5 " " " 135 "	none
8	" 4 " " " 136 "	.31
9	" 4 " " " 137 "	none
10	" 3 " " " 138 "	.13
11	" 3 " " " 139 "	none
12	" 3 " " " 140 "	.13
13	" 4 " " " 140 "	.13
14	" 5 " " " 140 "	.18
15	" 7 " " " 140 "	none
16	" 10 " " " 140 "	none
17	Immersed 10 min. in water at temp. of 140 deg. and cooled	.13
18	Untreated	2.1
	BLUESTONE.	
19	Dipped in a solution of 1 lb. of bluestone to 1 gal. water	.22
20	" " 1 " 2 "	.40
21	Dipped 5 min. in solution of 1 lb. bluestone to 2 gal. water	none
22	Dipped in a solution of 1 lb. of bluestone to 3 gal. water	1.20
23	Dipped 10 min. in a solution of 1 lb. bluestone to 3 gal. water	none
24	Untreated	1.8

TABLE V.—CONTINUED.

No. plat.	TREATMENT.	Per ct. smutty heads.
25	Dipped in a solution of 1 lb of bluestone to 3.5 gal. water....	1.3
26	Dipped 10 minutes in a solution of 1 lb. of bluestone to 3.5 gallons water....	.13
27	Dipped in a solution of 1 lb. of bluestone to 4 gal. water......	.09
28	Dipped 10 min. in solution of 1 lb. bluestone to 4 gal. water..	.13
29	Dipped in a solution of 1 lb. of bluestone to 5 gal. water.....	.27
30	Dipped 30 min. in solution of 1 lb. bluestone to 5 gal. water...	.04
31	Untreated....	1.11

It will be seen that the per cent. of smut was in no case large, not even in the untreated plats, and that in almost every instance the per cent. was greatly reduced by the treatment. An immersion of ten minutes at 132 deg., without after cooling by dipping in cold water, was effective. The experiment indicates that a less time in water of a higher temperature serves the purpose fully as well. The higher degree of heat seemed in no way to affect the vitality of the seed.

That immersed in water at a temperature of 140 deg. for ten minutes gave a stand equal to any of the others and showed fully as much vigor in its growth. However, since numerous experiments show the temperature of 132 deg. to 135 deg. to be effective, it is best to keep the temperature of the water within this limit. The ordinary cheap thermometers were found wholly unreliable for this work, their indications for the same temperature varying more than five degrees.

The dipping in the bluestone treatment was intended to be sufficient to thoroughly wet every kernel of the wheat, but this seemed not as effective as an immersion for a brief period in a weak solution. The only instance in which the smut was entirely prevented by the bluestone treatment was shown on plats Nos. 21 and 23, where the immersion was for five minutes in a solution of one pound of bluestone to two gallons of water, and ten minutes in one pound to three gallons of water. None of the plats showed any damage as a result of this treatment.

In the bluestone treatment either dipping or sprinkling may be followed successfully, according to the convenience of the farmer. The solution in either case may be made by using two pounds of bluestone to five gallons of water. Where a quantity is dipped and spread out to dry it will soak up as much proportionately of the solution in draining and drying as the small quantity used in the experiment did by the few minutes immersion.

In sprinkling the grain must be shoveled over often enough to thoroughly wet every kernel, and it should remain in a pile from twenty to thirty minutes, without being spread out to dry, in order that the solution may have time to destroy the smut.

In dipping, ordinary gunny sacks for the grain, and a barrel for the solution, will serve the purpose very well. An additional quantity of the solution should be kept on hand in another vessel, so the barrel may be replenished as often as necessary.

In all cases the grain should be thoroughly cleaned before applying the remedy.

BARLEY SMUT.

The remedies used to prevent barley smut were identical with those used in the oat experiment, but since not a single smutty head of barley was found during the season in any of the barley plats, treated or untreated, any detail of the experiment would be of little interest.

OAT SMUT.

The remedies tested for smut in oats comprised the following: Hot water, the temperature ranging from 126 deg. to 150 deg., and the time of immersion from dipping to ten minutes; potassium sulphide, the strength of the solution varying from 1.66 to five per cent.; corrosive sublimate, the solution containing from one ounce to twelve quarts of water to one ounce to two quarts; zinc chloride, zinc sulphate, and potassium bicarbonate, the strength of the solution of each ranging from one to five per cent.; and potassium permanganate, the strength of which solution varied from .2 to 1 per cent.

TABLE VI.

Treatment of Seed Oats for Smut.

No. plat.	TREATMENT.	Per ct smutty heads.
1	Untreated	1.06
2	Immersed 10 minutes in water at a temperature of 126 deg. F.	none
3	“ “ “ “ “ 128 “	none
4	“ “ “ “ “ 129 “	none
5	“ “ “ “ “ 130 “	none
6	“ “ “ “ “ 131 “	none
7	“ “ “ “ “ 132 “	none
8	“ 8 “ “ “ 132 “	none
9	“ 5 “ “ “ 132 “	.23
10	“ 10 “ “ “ 133 “	none
11	“ 8 “ “ “ 133 “	none
12	“ 5 “ “ “ 133 “	none
13	“ 10 “ “ “ 134 “	none
14	“ 5 “ “ “ 134 “	.04
15	“ 8 “ “ “ 135 “	none
16	“ 5 “ “ “ 135 “	none
17	“ 5 “ “ “ 136 “	.04
18	“ 5 “ “ “ 137 “	.08
19	Untreated	1.10
20	Immersed 5 minutes in water at a temperature of 138 deg. F.	none
21	“ 5 “ “ “ 139 “	.27
22	“ 3 “ “ “ 140 “	.23
23	“ 5 “ “ “ 140 “	none
24	“ 5 “ “ “ 141 “	none
25	“ 5 “ “ “ 142 “	none
26	“ 3 “ “ “ 142 “	.15
27	“ 3 “ “ “ 143 “	.15
28	Immersed 5 minutes in water at a temperature of 143 deg. F. and cooled	.08
29	Immersed 3 minutes in water at a temperature of 144 deg. F. and cooled	none
30	Immersed 3 minutes in water at a temperature of 144 deg. F.	.04
31	Dipped in water at a temperature of 145 deg. F.	.15
32	“ “ “ 146 “	.08
33	“ “ “ 147 “	.66
34	“ “ “ 148 “	.78
35	“ “ “ 149 “	.19
36	“ “ “ 150 “	.47

TABLE VI.—CONTINUED.

No. plat.	TREATMENT.	Per ct. smutty heads.
	POTASSIUM SULPHIDE.	
37	Dipped in a solution of 50 grams of potassium sulphide to 1 quart of water	.43
38	Dipped 15 minutes in a solution of 50 grams of potassium sulphide to 1 quart of water..	none
39	Dipped in a solution of 50 grams of potassium sulphide to 2 quarts of water..	1.41
40	Dipped 20 minutes in a solution of 50 grams of potassium sulphide to 2 quarts water	.08
41	Dipped in a solution of 50 grams of potassium sulphide to 3 quarts of water	1.45
42	Dipped 30 minutes in a solution of 50 grams of potassium sulphide to 3 quarts of water	.63
44	Soaked 4 hours in a solution of 50 grams of potassium sulphide to 3 quarts of water..	none
	CORROSIVE SUBLIMATE.	
45	Dipped in a solution of 1 ounce to 2 quarts of water........	.39
46	" " 1 " 3 " "	.04
47	" " 1 " 4 " "	.27
48	" " 1 " 5 " "	.12
49	" " 1 " 6 " "	.12
50	" " 1 " 12 " "	.08
51	Soaked 12 hours in a solution of 1 ounce to 12 qts. water.....	.12
52	Untreated	.94
	ZINC CHLORIDE.	
53	Dipped in a solution of 50 grams to 1 quart of water........	.78
55	" " 50 " 2 " "	1.06
56	" " 50 " 3 " "	.57
57	" " 50 " 5 " "	.35
	ZINC SULPHATE.	
58	Dipped in a solution of 50 grams to 1 quart of water........	.29
59	" " 50 " 2 " "	none
60	" " 50 " 3 " "	.66
61	" " 50 " 5 " "	.15
	POTASSIUM BICARBONATE.	
62	Dipped in a solution of 50 grams to 1 quart of water........	.12
63	" " 50 " 2 " "	.43
64	" " 50 " 3 " "	.23
65	" " 50 " 5 " "	.15
	POTASSIUM PERMANGANATE.	
66	Dipped in a solution of 10 grams to 1 quart of water........	.59
67	" " 10 " 2 " "	.67
68	" " 10 " 3 " "	1.02
69	" " 10 " 5 " "	1.53

It will be seen from the above table that hot water was the most effective of the remedies tested in preventing smut. The results of this experiment indicate that an immersion of ten minutes at the lower temperatures is a surer preventive than the shorter time of immersion at the higher temperatures.

There was no perceptible difference made in the germinating power of the grain by the different degrees of heat, or by the different methods of treatment.

BULLETIN NO. 11.

MONTANA

AGRICULTURAL

EXPERIMENT STATION

DEVICES FOR OBTAINING A CONSTANT FLOW IN LATERALS WITH VARIABLE HEADS IN THE MAIN CANALS OR RESERVOIRS.

Bozeman, Montana, June, 1896.

The Avant Courier,
Book and Job Printers,
Bozeman, Mont., '96.

MONTANA AGRICULTURAL

EXPERIMENT STATION.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman.
Peter Koch, Secretary and Treasurer	Bozeman.
George Kinkel, Jr., Vice-President	Manhattan.
Walter Cooper	Bozeman.
Nelson Story	Bozeman.

EXPERIMENT STATION STAFF.

S. M. Emery	Director and Horticulturist.
Luther Foster, M. S. A.	Agriculturist and Botanist.
F. W. Traphagen, Ph. D., F. C. S.	Chemist.
W. L. Williams, V. S.	Veterinarian.
A. M. Ryon, C. E.	Irrigation Engineer.

Post Office Address and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

Montana Experiment Station,
Bozeman, Montana.

NOTICE: The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Experiment Station.

Bulletin No. 11. ◆ 'June, 1896.

DEVICES FOR OBTAINING A CONSTANT FLOW IN LATERALS WITH VARIABLE HEADS IN THE MAIN CANALS OR RESERVOIRS.

A. M. RYON.

With the continually growing demand for water for the purpose of irrigation, and a supply which is already severely taxed, the people of the arid west will of necessity be obliged to take every precaution against the waste of this life giving fluid.

It is apparent that our present loose systems of measurement and apportionment must give way in time to the more exact methods already known and practiced by hydraulicians in the more populous sections.

In using water for irrigation, it is often difficult to readily distinguish differences of flow equal to 10% or 15% and for this reason possibly we adhere to old methods of measurement where such differences are only too common. For instance suppose we assume an opening 16⅔ inches long and 6 inches high, passing 100 Montana Statutory inches, with the required head of 6 inches over the center of the opening. Suppose the width of the box to be equal to the full length of the opening, a condition frequently seen, and that we ignore the head which causes the velocity of the water approaching the opening, which, although contrary to statute requirments, is customary in Montana, the discharge will then be very nearly $Q=.68\times 8.02 (.5)^{\frac{1}{2}}\times .7=2.6$ cu. ft. per second, as we have suppressed contractions on three sides.

The area of the cross section of the approaching water will be 16⅔″×9″=1.04 sq. ft. and the velocity will be $\frac{2.6}{1.04}=2.5$ ft. per second.

The head causing this velocity would amount to $h=\frac{V^2}{2g}=0.097$ ft.=1.13 inches.

In other words, although we have apparently a head of 6 inches over the center of the opening, we really have a head equivalent to $h+1.13=7.13$ inches, and if we consider the effect of the velocity in reducing the contraction of the escaping stream, the practical head is further increased.

The effect of thus increasing the head 0.1 foot is to increase the flow over 10 per cent. Yet many such boxes are in existence and their use remains unchallenged.

The law contemplates the reduction of this velocity of this approach to a minimum and as this would necessitate the use of wider boxes, end contractions would be introduced in the escaping jet and the flow would be reduced to less than 2.6 cu. ft. per second; but as compliance with the law would necessitate more expensive boxes as well as reduce the amount of water flowing through the orifice, it is not surprising that the box described above is so popular.

It has been shown that where 200 Montana statutory inches are measured through one orifice and 36 inches are measured through another, an increase of 6 per cent unit of area is obtained where the larger amount is measured.* In other words, where 200 inches are measured, a statutory inch contains 1.06 times as much water as a statutory inch where 36 inches are measured.

Where larger amounts are measured this difference is still more marked. The Romans of early days considered this matter of sufficient importance to warrant them in passing a law restricting the amount which could be measured through any one orifice.

---

* Journal of Associated Engineering Practices, January, 1895. Measurement of Water, by A. M. Ryon.

When water is drawn from a reservoir or canal for the purpose of feeding laterals, the fluctuations of the surface level are apt to cause a variation in the amounts received by those using water from the laterals. Where all users are subject to the same variations, there may be no objection raised. But in cases where it is desirable that a constant flow be maintained some special device becomes necessary to produce this result. The following table will show the percentage of increased flow due to increasing the head over a given orifice, 6″ high and 16⅔″ long.

Approximate Discharge Through an Opening 16⅔ Inches Long and 6 Inches High. Contraction Suppressed on Three Sides.

Head over the center of the opening, in ft.	Flow in second feet.	Difference.	Percentage of increase in discharge.
0.5	2.67	....	....
0.6	2.97	0.3	10
0.7	3.19	0.2	18
0.8	3.43	0.2	26
0.9	3.62	0.2	34
1.0	3.82	0.2	41
2.0	5.34	1.5	98
3.0	6.64	1.3	146
4.0	7.63	0.9	183
5.0	8.53	0.9	216
6.0	9.34	0.8	246
7.0	10.09	0.7	273
8.0	10.80	0.7	300
9.0	11.43	0.6	324
10.0	12.06	0.6	346

It will be seen from the above table that the greater the total head over the orifice the less the effect of slight fluctuations on the discharge. As an example in the case given above, if the head increases from 0.5 to 0.8, involving a rise of water of but 0.3 of a foot, the increased discharge amounts to 0.7 cu. ft. per second, or an increase of 26 per cent. In order to increase the discharge 26 per cent when the head is 10 ft. it would be necessary to increase the head to 16 ft. For this reason where it is possible to place a regulating gate at a distance of several feet below the surface of the canal a practically constant flow may be obtained notwithstanding minor fluctuations in the surface of the water of the canal. The main objection to such an arrangement lies in the necessary loss of head in delivering water from the canal to the lateral, a fatal defect under most conditions.

In this case in order to measure the water, a statutory inch box or a weir should be placed below the gate; the supply to be regulated as desired by opening or closing the gate.

* A prize of $500 was awarded to Chas. A. D. Ebro by the minister of water supply of Victoria for a module consisting of a floating cylinder having notches or weirs on its upper edge, the cylinder having no bottom and being connected with a duct underneath by means of a leather bellows arrangement, which opens and closes as the cylinder rises and falls.

The amount of water delivered may be regulated by varying the depth to which the cylinder is sunk. The leather joint would seem to be open to practical objections.

H. L. Decker of Teller, Colorado has a device consisting of a siphon arranged to float upon a raft, and thus maintaining a constant distance between the mouth of the siphon and the level of the water. The arrangement would seem to offer some advantages. This module is shown in Fig. 1.

---

* Bul. 27. Colo. Exp. Sta., L. G. Carpenter.

It is claimed that this siphon module, so called, will clear itself of air when running at full capacity and that the flow may be decreased or shut off at will. It is said that siphons 30 inches in diameter and delivering 1000 statutory inches have been successfully operated.

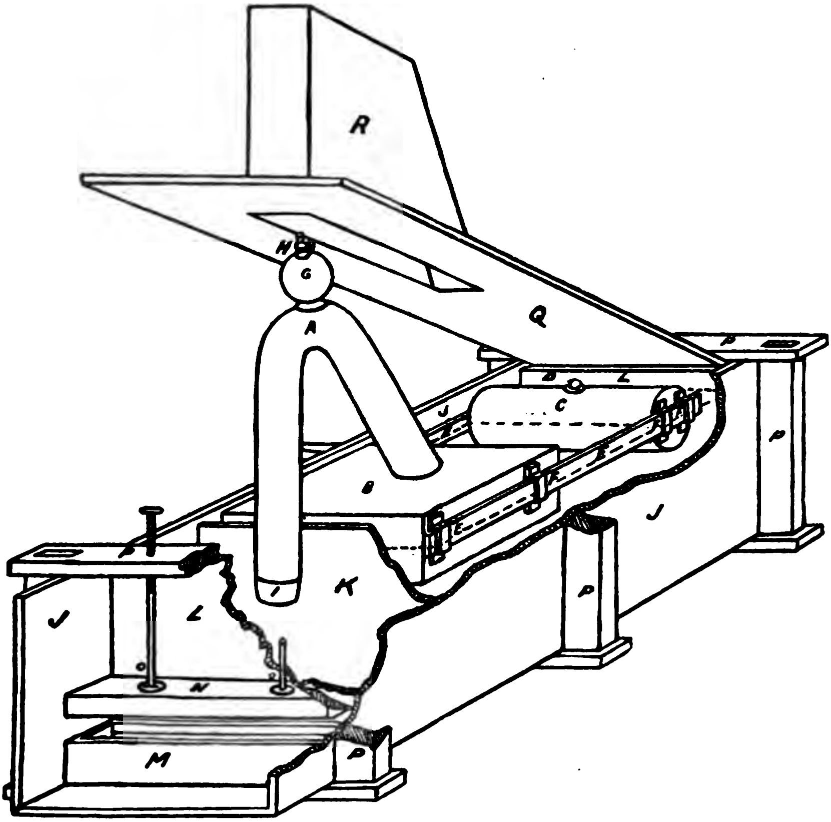


Fig. 1. Decker's Siphon Module and Automatic Pro-Rater.

A device, consisting of a box supported by a float and connected to the outlet by a pipe with a flexible joint, has been tried in Colorado. The box is provided with an orifice sufficiently large to admit the required amount of water.

This module would probably be practicable if a satisfactory flexible joint could be provided; and this difficulty seems to be an obstacle to its successful operation.

At the Isabella I. canal of Spain is a module which depends for its action upon the opening and closing of a circular hole by a cone-shaped plug. The motion of the plug is actuated by the rise and fall of the surface of the water in the main channel. This arrangement involves some loss of head, but is said to give fairly satisfactory results otherwise.

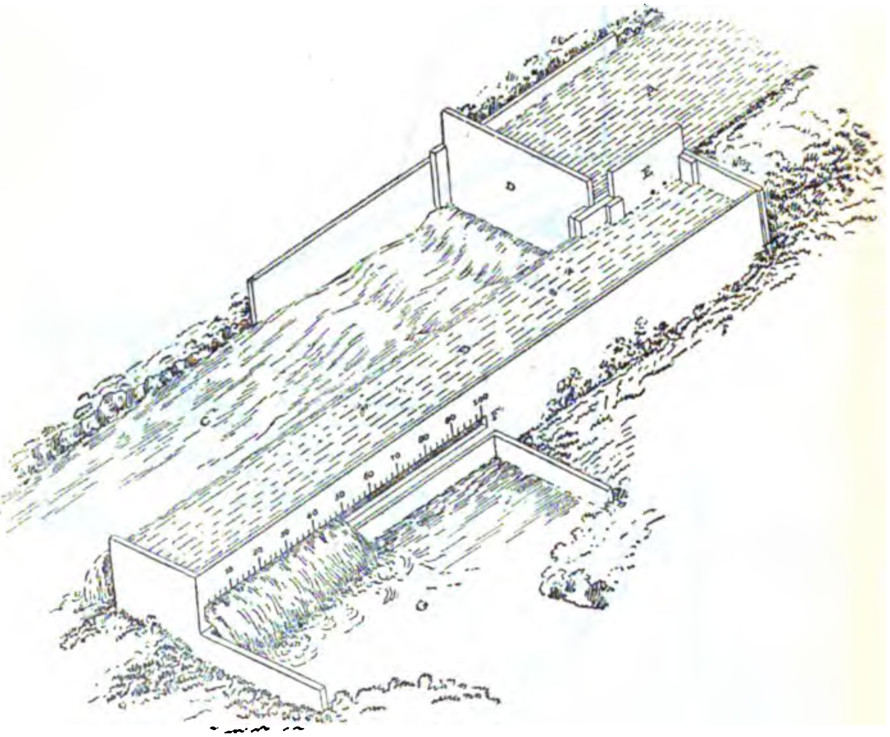


Fig. 2. Spill Box.

The spill box (see Fig. 2), designed by A. D. Foote, of Idaho, has deservedly attracted considerable attention at the hands of writers on irrigation and been used in connection with a number of canals in this country. The illustration shows very clearly the operation of this box. The gates D and E cause a portion of the water to flow into the box B, part of the water from B flows into the lateral C, the remainder flows back over a long weir into the main channel. The longer this weir in comparison to the length of the orifice, the more constant the head. Instead of an orifice a weir may be used to feed the lateral.

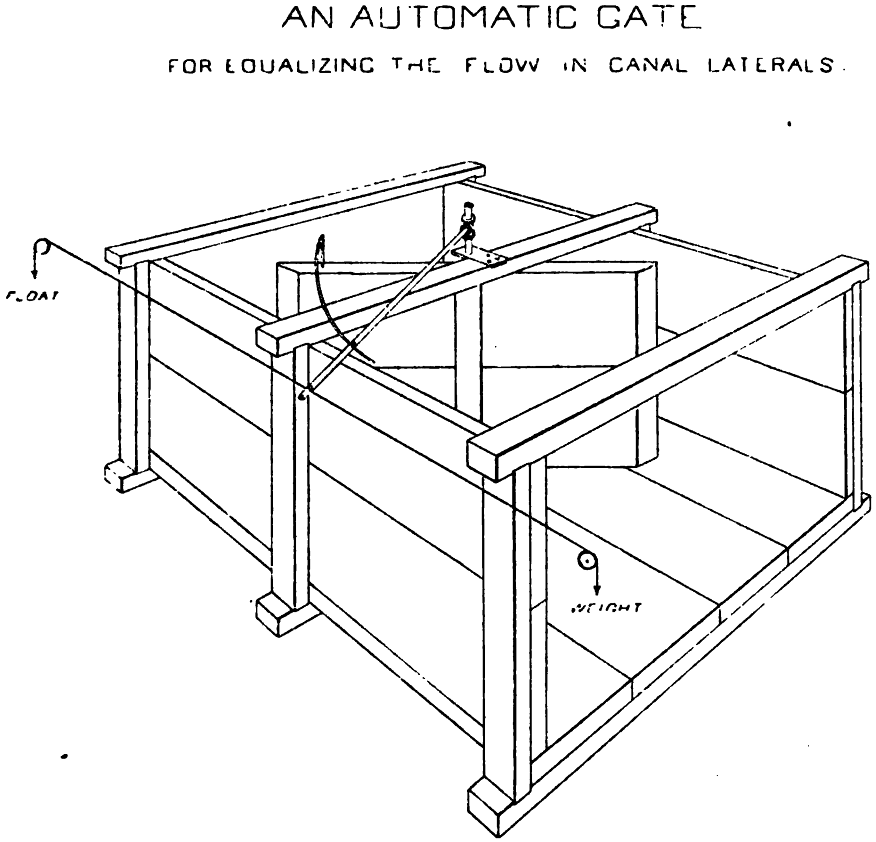


Fig. 3.

These weirs are frequently arranged in pairs, so that laterals may be taken out from opposite sides of the canal.

For practical purposes these spill boxes give excellent results, but they have the objection of involving a loss of head in the main canal of from say, six inches to one foot. This may or may not be a serious drawback, according to circumstances.

Fig. 3 shows a device designed by the writer. It consists of an ordinary box containing a gate which operates around a vertical axis. The gate is made of 2-inch plank, nailed to 2″x 4″ joists. Floor flanges are attached by screws to the top and bottom of the middle joist, and short lengths of ¾-inch pipe are screwed into the floor flanges. Pieces of bar iron ¼x2 inches, with holes bored slightly larger than the pipe, act as bearings, leaving the gate free to rotate in a manner similar to that of an ordinary stove-pipe damper. A lever, consisting of ¾-inch pipe, is used to open and close the gate. This lever is free to rotate about the axis of the gate unless prevented by the ¼-inch curved iron rod shown in the plate. The curved ¼-inch iron rod passes through a hole bored in the ¾-inch pipe and is secured with a set screw. In order that the lever may turn freely about the axis of the gate, the T pipe fitting at its extremity is reamed out so that it slips easily over the short piece of pipe on the gate. A rope is attached to the lever at any desired distance from the axis. This rope passes over a pulley to a float made of 2-inch plank, 4 feet square, placed in the main canal. The other end of the rope is attached to a weight. When the water in the main canal raises the float is lifted and allows the weight to close the gate. As the pressure of the water on each side of the axis is equal, there is no tendency for the gate to either open or close itself unless influenced by the action of the float. It is not necessary that the gate be made to fit the cross section of the box very closely.

Plate 1 shows the results of some experiments made with this gate. A measuring weir was placed just below the gate and the column marked "Head in Feet" represents the height of the surface of the water behind the gate, above the crest of the weir. The figures at the bottom of the plate represent the number of cubic feet of water flowing per second. The water was allowed to raise slowly behind the gate, and the increased flow, if any, over the weir was noted. For instance, when the gate was closed and not allowed to open, it was found that when the head, back of the gate was 0.4 feet, the leakage amounted to about 0.6 cubic feet per second, and when the head was increased to 1.4 feet, the leakage was a little less than 1.5 feet per second. If, on the other hand, the gate is kept wide open, the flow varies from about 1.8 second feet for a head of 0.4 feet to 10.4 second feet for a head of 1.4 feet.

In the various cases lettered A, B, C, etc., the gate is set so as to allow various amounts of water to pass through, and the lever is lengthened or shortened, as may seem desirable. In Case A the gate was properly set for a flow of a little over 2 second feet, or say about 80 statutory inches, the head in the main canal varying 6 inches without influencing the flow more than 0.2 cubic feet, or 10 per cent., without the gate the flow would have varied about 88 per cent., with a statutory box the increase would have been about 41 per cent.

In Case E the gate was set about right for 100 statutory inches, and between the heads 1 foot and 1.4 feet there was practically no variation in the volume discharged.

In the majority of cases shown the lever was evidently too long.

This device involves no loss of head in the main canal, but involves a loss of head in the lateral amounting from 0.9 feet in Case A to about 0.6 feet in Case H. in addition to the head used by the measuring box. A gate of this size could be used to advantage for amounts up to 3 cubic feet per second, or to 120 statutory inches.

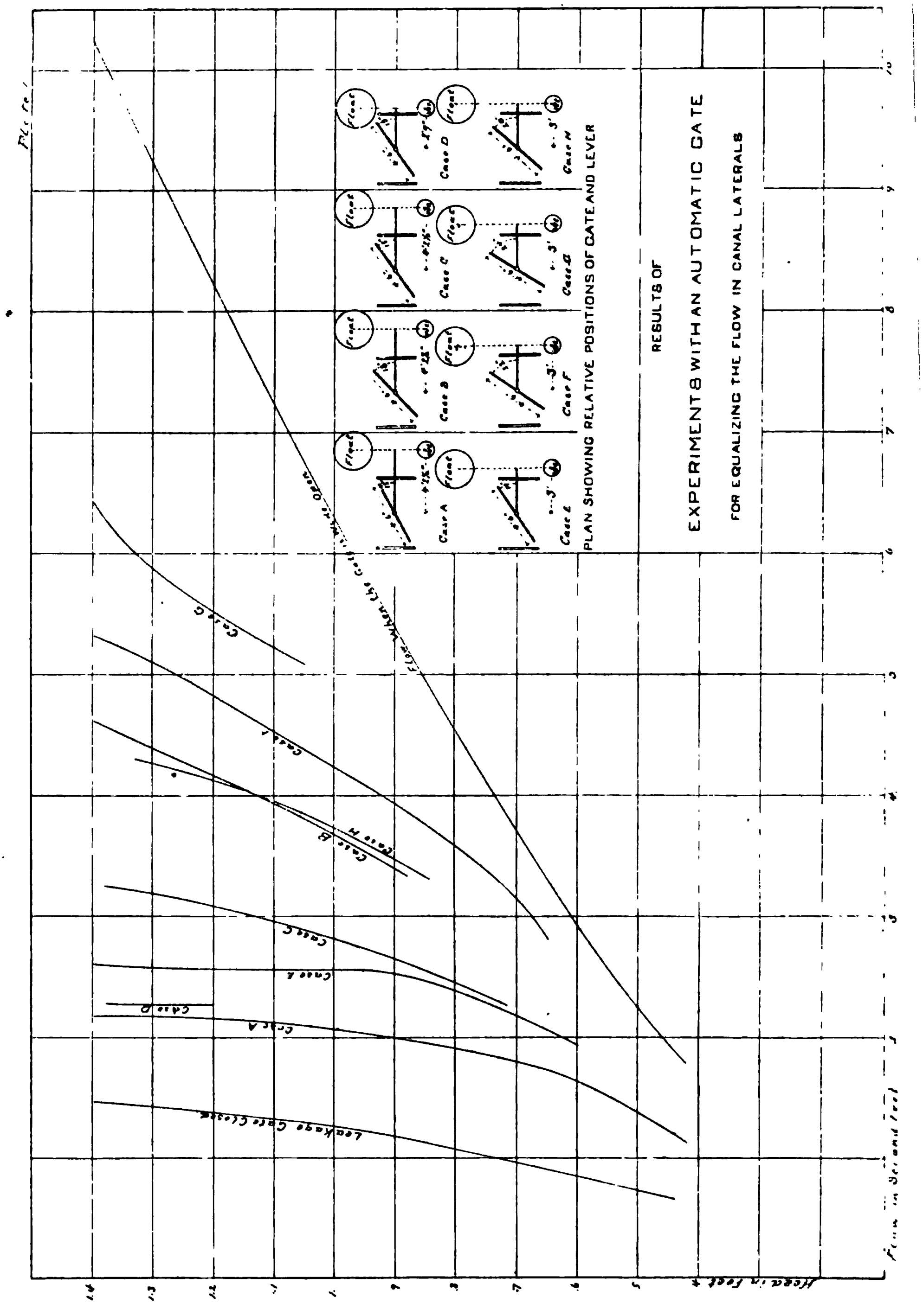


Plate I
RESULTS OF
EXPERIMENTS WITH AN AUTOMATIC GATE
FOR EQUALIZING THE FLOW IN CANAL LATERALS
PLAN SHOWING RELATIVE POSITIONS OF GATE AND LEVER
Float
Case A
Case B
Case C
Case D
Case E
Case F
Case G
Case H
Flow when the Gate is wide open
Leakage Gate Closed
Head in feet
Flow in Second Feet
1.4
1.3
1.2
1.1
1.
.9
.8
.7
.6
.5
.4
1
2
3
4
5
6
7
8
9
10

BULLETIN NO. 12.

MONTANA

AGRICULTURAL

EXPERIMENT STATION

THIRD ANNUAL REPORT

...OF...

TREASURER, DIRECTOR, HORTICULTURIST, AND CHEMIST,

...AND...

BULLETIN ON THE SPAYING OF MARES.

Bozeman, Montana, September, 1896.

Bozeman, Mont.,
The Avant Courier Publishing Co.,
1897.

MONTANA AGRICULTURAL
EXPERIMENT STATION.

LETTER OF TRANSMITTAL.

BOZEMAN, MONTANA, September, 1, 1896.

To His Excellency, John E. Rickards, Governor of Montana:

DEAR SIR: I have the honor to transmit to you herewith in accordance with law, the third annual report of the Montana Agricultural Experiment Station.

Respectfully,
S. M. EMERY, Director.

EXECUTIVE BOARD.

LESTER S. WILLSON, President	Bozeman.
PETER KOCH, Secretary and Treasurer	Bozeman.
GEORGE KINKEL, JR., Vice-President	Manhattan.
WALTER COOPER	Bozeman.
NELSON STORY	Bozeman.

EXPERIMENT STATION STAFF.

S. M. EMERY	Director and Horticulturist.
FRANK BEACH, M. S	Agriculturist.
F. W. TRAPHAGEN, Ph. D., F. C. S	Chemist.
W. L. WILLIAMS, V. S	Veterinarian.
JAMES D. BORROWS	Farm Foreman.

Post Office Address and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director,

MONTANA EXPERIMENT STATION,
Bozeman, Montana.

NOTICE: The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Report of the Treasurer of the Board.

The Montana Experiment Station, in Account With The United States Appropriation, 1895–96.

DR.

To Receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30th, 1896, as per Act of Congress, approved March 2, 1887	$15,000.00
To Sales Farm Produce	1,235.32
Total	$16,235.32

CR.

By Salaries	$ 7,704.15
Labor	2,820.12
Publications	498.30
Postage and Stationery	105.35
Freight and Express	197.85
Heat, Light and Water	318 11
Chemical Supplies	380.76
Seeds, Plants and Sundries	532.18
Fertilizers	30.00
Feeding Stuffs	50.11
Library	165.57
Tools, Implements and Machinery	426.13
Furniture and Fixtures	60.50
Scientific Apparatus	345.47
Live Stock	498.60
Traveling Expenses	106.80
Contingent Expenses	10.00
Buildings and Repairs	750.00
Dwelling and Wagon House	1,235.32
Total	$16,235.32

I hereby certify that the above is a true and correct statement of the receipts and expenditures of the Montana Experiment Station for the fiscal year ending June 30, 1896.

PETER KOCH, Treasurer.

We, the undersigned, duly appointed auditors, certify that we have examined the above account and and find it correct.

NELSON STORY,

ATTEST:—PETER KOCH, Secy. WALTER COOPER.

Dated at Bozeman, this 1st day of Sept., 1896.

Montana Experiment Station.

Bulletin No. 12. **Sept., 1896.**

Annual Report of the Director, for the Fiscal Year Ending June 30, 1896.

STATION STAFF.

In March of the current fiscal year, the resignations of Professors Ryon and Foster, were accepted to take place July 1st. The result of these resignations was to materially abridge Station work during the last half of the year; the field work for 1896 of the Agriculturist was conducted by the Horticulturist until July 15, while irrigation experiments were temporarily abandoned pending the employment of an irrigation engineer.

FARM BUILDINGS.

The quota of Government funds applicable to construction of buildings, was used in the completion of the second floor and laying a rough floor in third story of Experiment building.

The second story, thus finished was subdivided into suitable apartments for the residence of the Director, and is thus used, while the third or attic floor, supplies needful storage room for plat grain samples, etc. The proceeds of the farm crops for 1895 were devoted to the construction of a farm dwelling house 32x35 feet, a story and a half in height, with cellar under the entire building, also a single story building, 24x40 feet for storage of wagons, machinery, etc.

These buildings were built by contract and cost $1,235.32 and in addition to this sum the labor of certain of the farm help was used in excavating for cellar and in construction of the cellar walls (which are of concrete) and in other rough work about the structures. The material used for outer walls of buildings, is peeled pine logs of uniform diameter and length. The buildings are lathed and plastered, are tasty, convenient, comfortable and durable, and were erected at much less outlay of time and money than would have been the case had the common materials been used.

Settlers in many parts of Montana are located conveniently to this kind of building material, and by using such for farm buildings can secure desirable permanent improvements, much in advance of the time when they could afford much more expensive material and skilled labor for the construction of frame or brick buildings. To such we would cheerfully on request supply data as to cost, style and method of construction of our farm buildings.

EXPERIMENT PLATS.

In addition to the annual "quality and quantity test plats" for grains, roots, etc., permanent grass plats consisting of 26 of the leading grasses and clovers were sown in tenth acre plats for purposes of comparison, for hay, grazing meadows, irrigation tests, and chemical analyses. It was discovered early in the season that owing to the land being infested with wild oats, that it was impossible to secure an even stand of the grasses and clovers. It was thought that by repeated mowings of the plats that the wild oats could be kept under control, but so persistent is this pest, that they headed out and matured seed so close to the ground that the heads could not be reached with a sickle bar, and while for ordinary purposes, the grass stands would have been sufficiently good, to warrant leaving them to fight it out with the wild oats, for supremacy and occupancy of the land, it was decided to condemn and plow up the plats as the irregularity of the stand was too great to admit of fair variety comparison.

The eradication of this and other plant pests is subject matter for serious consideration and experiments in exterminating the same.

GENERAL FARM CROPS.

The following table shows the acreage and yield of the farm crops of the present fiscal year:

Barley, 37½ acres, yield per acre $42\frac{62}{75}$ bu.
Oats, 19 acres, yield per acre $60\frac{12}{19}$ bu.
Peas, $6\frac{95}{100}$ acres, yield per acre $22\frac{15}{100}$ bu.
Flax, 10 acres, yield per acre $11\frac{5}{100}$ bu.
Wheat, 12 acres, yield per acre $23\frac{7}{12}$ bu.
Rye, 3 acres, yield per acre 12 bu.

Taken as a whole the farm crop of '95 compares favorably with that of '94, and gives ample proof that future successful farming in the Gallatin Valley depends more upon skilful, intelligent rotation, than upon summer fallowing. The barley shows a decreased yield of $1\frac{13}{75}$ bu. per acre less than in 1894. Nearly half of the barley was on land on which barley grew in 1894 and while the quality grown was very choice, the yield per acre was less than half that grown on land sown to peas the previous year.

In the case of barley following barley, there is not sufficient nitrogen in the soil to give the young plant an early and vigorous impulse, it does not stool as it should and the result is that with the same amount of seed sown, the stand is thin, the straw short, and the yield insufficient, as compared with barley sown in the proper rotation.

The oat crop of 1895 followed in large part the oat crop of '94, with an increased yield of $18\frac{12}{19}$ bu. per acre. Upon two-thirds of the land, stable manure was applied upon fall plowing, at the rate of forty, 2 horse loads per acre. This was well disked in before seeding, and had the manure been well rotted and applied to the entire piece, it is safe to assume that the crop yield would have been double that of '94. In parts of the field, the manure contained too much long straw, which prevented the manure from being worked down into the soil and made an irregular deposition of the seed and increased the tendency of the soil to dry out. There was also an unequal distribution of manure in places, the result of pitching from the wagon with forks and in such places the grain grew too rank, fell down soon after heading and did not fill and ripen evenly.

The Canada field peas of '95 show a decreased yield of $14\frac{85}{100}$ bu. per acre from that of '94. It was thought that the crop of '94 did not ripen properly, and that it was owing to the application of water. The crop of '94 was twice irrigated. But a small part of the pea field of '95 was irrigated, such as was, having been done by waste water. The crop suffered materially from lack of water, with an attendant decreased yield. The name, "Canada field pea" is a very ambiguous term, as there are said to be 79 varieties of "Canada pea." The sort with which we are experimenting does not attain growth under irrigation, until late in the season, and fresh blooms and dead ripe peas are often found on the same plant. The threshed pea straw is an excellent forage plant for work horses, and is fed to good advantage in our barns.

The wheat crop of '95 shows a decreased yield of five and five-twelfths bu. per acre, as compared with the crop of '94. Nearly half the '95 crop was from seed grain grown by the Station Agriculturist. It was our desire to produce choice seed grain for distribution in small quantities. At heading time it was observed that owing to impurity of seed sown, that it would not produce desirable seed, and to save the expense of hand-harvesting small areas, it was decided to cut the various sorts at one operation with the binder.

The result was that there was a large loss sustained by irregular ripening and consequent shelling of grain, fully as much or more having thus been lost, than would suffice to bring the '95 yield, up to the average of '94.

An interesting and profitable experiment was conducted in the application of well rotted manure to growing grain, with the "Kemp & Burpee" manure spreader, at the rate of twenty loads per acre. This application was continued as late as June 26th. The wagon and team in passing over the growing grain, left it in a very ragged condition, but water was applied within ten days and it speedily rallied and made a much finer growth than that portion of the field, not thus treated.

The '95 rye crop showed a yield of twelve bu. per acre against twenty-six in '94. This was owing in part to a difference in soil, the '95 crop being on a much lighter soil. The season of germination was also unfavorable, and the stand was not nearly so good.

CLOVER.

Encouraged by the results from seeding red clover with grain in '94, it was determined to sow clover upon all barley land. This was done, using medium red clover seed at the rate of 7 lbs.per acre, sown with a Cahoon, hand broad-cast seeder from seven to ten days after the grain was sown, afterward crossing the seeder marks with a fine slant tooth harrow. The seed germinated evenly and an excellent stand resulted. Upon all lands on which barley followed barley the stand and growth were phenomenally good, because in addition to the light growth of straw on these tracts (which gave the clover a better exposure to light and air,) the crops received an extra irrigation, which was given to stimulate the barley to a stronger growth, while on lands following peas, it was deemed unwise to give the second watering on account of the heavy growth of barley and its tendency to fall down.

There is no difficulty in securing a fine stand of clover on all grain land regardless of the character of the nurse crop. The principal difference noted, was seen on stubble lands after the grain crop was harvested. That on which the lightest grain grew might have been fall plowed to good advantage, the growth of clover, both of top and root being sufficiently heavy to warrant turning under, for green manuring.

Further experience establishes more firmly our belief in the unwisdom of summer fallowing as a profitable mode of farming. In Gallatin county, where 340 acres is the average sized farm, it may not be possible to sow entire farms each year to small grain, and those producing small grain exclusively, to the neglect of diversified farming, may not be able to crop all the land in this manner, but it is entirely possible to seed, say, a third ot each farm to clover each season, turning this under at the end of each period of three years, and the profit accruing from clover culture will most certainly amount to sufficient to pay taxes and interest upon such lands that are thus used. The question of clover growing opens up an extensive field for speculation, both financial and mental.

Clover fields comprising two-thirds, or even one-half, of the area of our farms would be beyond the present demand for hay, and to find a market therefore would necessitate dairying, swine-feeding and fattening sheep and cattle. If the lands can be seeded at an expense of $1.00 per acre and such expense be incurred each second or third year, with the result that the productive ability of the land be doubled, and from two to five tons per acre of superior forage be produced there should be ways and means found to market the increased forage upon the farm. Confirmation of this is found in consideration of the Gallatin county crop returns for '95. The average of the crops are as follows:

Oats 54 bu. per acre.
Spring wheat 31.8 bu. per acre.
Winter wheat 31 bu. per acre.

Barley 41.4 bu. per acre.
Peas 35 bu. per acre.

By comparison it will be noted that the oat and barley crops of the Station farm exceed the general average of of the county, and that the Station farm pea and wheat crops are respectively 50 per cent and 33 per cent less than the average and this difference has been explained in a manner that will not cause this increased gain to be attributed solely to the custom of summer fallowing as practiced in Gallatin county. We note by proper returns for the county that more than three-fourths of the Gallatin farmers make a practice of summer fallowing, and that the average per farm, thus treated in '95 equalled 133 acres, certainly a vast amount of land in the aggregate to be unemployed, unless there be a better reason for so doing than is indicated by the yearly crop statistics of the valley. In farther confirmation of our opinion, may be cited the experience of Messrs. Law & Gilbert of Rothamstead, England, who have been conducting scientifically a private experiment farm for upwards of 50 years, and whose deductions and conclusions stand unchallenged for reliability in the scientific world. On lands farmed continuously to wheat without fertilizers for 50 years and similar lands summer fallowed alternate years, also without fertilizers, they show that the lands continuously farmed to wheat, have produced in the aggregate substantially as much grain, as have the lands that have been fallowed each alternate season. Had a system of rotation of crops been pursued on the unfallowed lands the aggregate increase of grain crops would have been much greater beyond question.

FARMERS' INSTITUTES.

Inability to secure railway transportation for workers engaged in institute work, has precluded engaging in this line of work, rightfully considered as among the most useful in which Station men can be engaged. It is confidently expected that this obstacle can now be overcome and that a limited number of meetings can be conducted in the state, during the coming year.

PRESS LIST.

Comparison of the press list of the current year with those of former years, will show a gratifying increase in numbers, both of Montana and other State publications. These publications come to us in exchange for Bulletins of this Station, and are of material benefit to the Station staff as well as to those students who take advantage of the opportunity to read them, which is freely extended. It is a source of regret that the list of State papers is not complete in our files, and that there are some Montana Editors who receive our Bulletins without sending their papers in exchange. This no doubt is owing to oversight and is here mentioned with the hope that the omission to place the Station upon their exchange list, will be promptly corrected.

The following newspapers and publications were kindly donated to the Station by the publishers during 1895-6. These are on file in the Director's office, for the use of the Staff, students and other interested readers:

St. Paul Dispatch, St. Paul, Minn.
Farming, Toronto, Canada.
Holstein Friesian Register, Brattleboro, Vt.
Forest Leaves, Philadelphia.
Orange Judd Farmer, Chicago, Ill.
Farm Reporter, Charleston, W. Va.
Irrigation Age, Chicago, Ill.
Ohio Valley Farmer, Cincinnati, Ohio.
Northwestern Printer, St. Paul.
National Stockman, Pittsburg, Penn.
Sanitary Inspector, Augusta, Maine.
Inland Poultry, Indianapolis, Indiana.
Southwestern Farm and Orchard, Las Cruces, N. M.
Western Field and Stream, St. Paul, Minn.
Jersey Bulletin, Indianapolis, Ind.
Farm News, Springfield, Ohio.
Farm Students' Review, St. Anthony Park, Minn.

Southern Farmer, New Orleans, La.
Elgin Dairy Report, Elgin, Ill.
Southern Cultivator, Atlanta, Ga.
Farm and Home, Springfield, Mass.
Northwest Magazine, St. Paul, Minn.
Farmers' Guide, Huntington, Ind.
American Fertilizer, Philadelphia, Pa.
National Nurseryman, Rochester, N. Y.
Farmers' Magazine, Springfield, Ill.
Northwestern Farmer, St. Paul, Minn.
Northwestern Agriculturist, Minneapolis, Minn.
Farm, Stock and Home, Minneapolis, Minn.
American Agriculturist, New York City.
Gardening, Chicago, Ill.
American Florist, Chicago, Ill.
Hoard's Dairyman, Fort Atkinson, Wis.
Minnesota Horticulturist, Minneapolis, Minn.
Practical Nurseryman, Huntsville, Ala.
Green's Fruit Grower, Rochester, N. Y.
Weekly Sun, Baltimore, Md.
Wisconsin Agriculturist, Racine, Wis.
Riverside, Red Wing, Minn.
Republican, Lake City, Minn.
Dorset Quarterly, Washington, Pa.
Poultry Monthly, Albany, N. Y.
Farmers' Call, Quincy, Ill.
Independent, Helena, Mont.
Sentinel, Boulder, Mont.
Avant Courier, Bozeman, Mont.
Chronicle, Bozeman, Mont.
Pioneer, Big Timber, Mont.
Times, Billings, Mont.
Belt Valley Times, Belt, Mont.
Call, San Francisco, Cal.
Weekly Tribune, Butte, Mont.
Campbell's Soil Culture, Sioux City, Iowa.
Gazette, Billings, Mont.
Inter Mountain, Butte, Mont.
Silverite, Missoula, Mont.
Inter Lake, Kalispell, Mont.
Tribune, Dillon, Mont.
Examiner, Dillon, Mont.
Western News, Hamilton, Mont.
Leader, Great Falls, Mont.
Tribune, Great Falls, Mont.

Democrat, Lewistown, Mont.
Stockgrowers' Journal, Miles City, Mont.
Yellowstone Journal, Miles City, Mont.
Missoulian, Missoula, Mont.
Mail, Philipsburg, Mont.
Red Lodge Picket, Red Lodge, Mont.
North West Tribune, Stevensville, Mont.
Madisonian, Virginia City, Mont.
Stockman and Farmer, Helena, Mont.
Rocky Mountain Husbandman, White Sul. Spgs., Mont.
The Rockies, Dillon, Mont.
Oregon Agriculturist, Portland, Or.
Sportsmen's Review, Chicago, Ill.
Southern States, Baltimore, Md.
Agricultural South, Atlanta, Ga.
Grange Visitor, Charlotte, Michigan.
Homestead, Des Moines, Iowa.
Montana Fruit Grower, Missoula.
Great Northern Bulletin, St. Paul, Minn.
Market Garden, Minneapolis, Minn.
Nebraska Farmer, Lincoln.
Republican, Missoula, Mont.
Standard, Anaconda, Mont.
The Forester, Princeton, N. J.
Wallace's Farmer, Ames, Iowa.
Success With The Garden, Rosehill, N. Y.
Yellowstone Recorder, Billings, Mont.
Enterprise, Livingston, Mont.
Western Mining World, Butte, Mont.
Public Ledger, Philadelphia, Pa.
College Exponent, Bozeman, Mont.
Missoula Messenger, Missoula, Mont.
Glendive Independent, Glendive, Mont.
Horticulture, Cuyahoga Falls, O.
Western Creamery, San Francisco, Cal.
Farmer's Voice, Chicago, Ill.
Farm Journal, Philadelphia, Pa.

DONATIONS.

We take great pleasure in acknowledging the receipt of the following contributions:

Mrs. H. C. Border, Bozeman, one package Tom Thumb seed pop-corn.

Paul Zuber, Paris, France, two packages Sainfoin.

The Deming Co., Salem, O., one Vermorel spray nozzle.

Sunset Seed and Plant Co., San Francisco, Cal., 29 packages sweet pea seed.

T. J. Lynde, Bozeman, 6 packages sugar beet seed.

J. C. Vaughan, Chicago, Ill., 23 packages flower and garden seed.

W. Atlee Burpee & Co., Philadelphia, Pa., 56 packages flower and garden seed.

U. S. Department of Agriculture, Washington, D. C., 75 packages vegetable seed.

Montana Plaster Co., Joliet, 2 sacks land plaster.

Director California Experiment Station, 2 packages Australian salt bush.

Joe Munger, Bozeman, Mont., 1 package Egyptian corn.

C. H. Dietz, No. 8, Gold St., N. Y., 2 packages Wohanka Ertragreicher beet seed; 1 pkg. Zuckerreicher beet seed.

Minnesota Flax Co., Minneapolis, 1 package flax fiber seed.

M. Flanagan, Billings, Mont., 3 lbs. broom corn seed.

DISCOUNTS.

A substantial discount from wholesale prices was made this Station by the John Deere Co., of Moline, Ill., for a single disk Secretary plow. This is a combined stirring and sub-soiling plow, and has proven to be a practical and effective implement.

INVENTORY OF PERSONAL PROPERTY.

The following inventory shows personal property belonging to the Experiment Station January 1, 1896:

Farm machinery and apparatus	$2,206.35
Veterinary appliances	252.80
Weather instruments	43.00
Chemicals	223.04
Chemical apparatus	1,676.43
Photographic apparatus	100.00
Posts, building logs, and stove wood	103.00

Stationery, cuts and miscellaneous supplies	206.47
Office furniture	444.47
Live stock	1,034.00
Farm house furniture	190.42
Total	$6,479.98

BULLETINS.

Four Bulletins of the regular series have been issued. Bulletin No. 8 contains the annual report and report of progress upon the parasitic ictero hæmaturia of sheep, thirty-two pages, 5,000 copies; No. 9, Potates, 24 pages, 5,000 copies; No. 10, Small Grains, 22 pages, 5,000 copies; No. 11, Devices for obtaining a constant flow in laterals with variable heads in main canals or reservoirs, 12 pages, 5,000 copies. These, with the present report, as Bulletin No. 12, will complete the full series due under the law at the close of the third fiscal year. The call for Bulletins has been such that a revision of the mailing list is imperative, with a view of cutting off the least desirable recipients.

The Legislature could, to good purpose enact a law, by which the Bulletins of this Station could be printed at State expense—this is done in some states—and would effect a material saving in the finances of the Station.

It would seem that the State could well afford to do this, inasmuch as it has never directly contributed one penny to the support of this institution. So far it owes its existence to the National Government and Gallatin county.

REPORT OF THE HORTICULTURIST.

The current year has not been an ideal one for the orchardist, the spring was late, and other pressing work, combined with the fitting of new land for the orchard site, made it too late when the trees were finally planted, to insure the new and strong growth and development, which is so important to secure the first season. Abnormally early and severe frosts prior to the natural period of leaf and wood ripening, had injurious effects upon fruit trees and plants, again; the heavy tenacious clay subsoil of the orchard retained moisture beyond expectation, and prolonged growth too late in the season, so much so that much of the foliage adhered to the tree until well along in the winter. In this respect the trees that were set in dynamited soil ripened up much better than those set in normal soil. These conditions coupled with the nature of the trees comprising the orchard, embracing as it does 138 different varieties of apples, crabs, plums, prunes, cherries, pears and apricots, varing as greatly in difference of hardiness, as in kinds, all gave reasonable grounds for expectation of considerable loss incident to the planting of so many tender varieties. The winter was not unusually severe, but the extremes of temperature were numerous and strongly defined, such as usually occasion severe injury to fruit trees. In addition to this, there was not that perfect and ideal protection afforded by a medium snow fall, which to be most valuable should fall in early winter and remain until well along toward spring. There were intervals of considerable duration, when the ground was entirely bare of snow, accompanied by sharp freezing weather.

There appeared to be no root injury, spite of these adverse conditions. Early in the season, the jack-rabbits began to girdle stems and tops of pendant limbs. To protect from these, the stems were wrapped with newspapers, from the base to the forks and these securely tied in place. This not only prevented the ravages of rabbits and field mice, but protected from sun scald as well. In addition to protecting the stems of the trees, measures were taken for the destruction of vermin by slicing sections of carrots and sprinkling these with arsenic. These were placed on sharpened sticks 12 to 18 inches in height which were stuck upright into the ground or in snow drifts along the outer rows of the orchard trees. By the use of these precautions the total damage from rodents was very small. The following shows the variety, and number of those planted, together with those living and dead.

APPLE LIST.

	SET	ALIVE	DEAD
Yellow Crimean	5	5	
Red Queen	6	6	
Grandmother	5	4	1
Gipsey Girl	5	5	
Bogdanoff	5	4	1
Persian	5	4	1
Royal Table	5	5	
12 M	5	5	
Rambour Queen	5	4	1
No. 257	5	4	1
Borsdorf	4	4	
Longfield	3	3	
Wealthy	5	5	
Alexander	2	2	
Tetofsky	5	5	
Arabskoe	2	2	
Fameuse	2	2	
Cross	1	1	
Gideon	3	3	
Veronesch	11	9	2
Anisette	4	4	
Zuzoff	5	5	
Aport	5	5	
Baiken	5	5	
Rosenhagen	5	5	
Orel No. 11	5	5	
Good Peasant	6	6	
Lead 3 N	7	6	1
Walbridge	2	1	1
Northern Spy	2	1	1
Gravenstein	2	1	1
Veronesch Rosy	3	3	
Grimes' Golden	2	2	
Red Bietigheimer	2	2	
Hurlbut	2	2	
Fall Pippin	2	2	
Ben Davis	1	1	
Golden Russet	5	5	
Keswick Codlin	2	2	
Red Astrachan	2	2	
Haas	3	3	
Okabena	3	3	

Thompson's	24	24	
Sutton Beauty	2	2	
Maiden Blush	2	2	
Duchess	5	5	
Scott's Winter	3	3	
Wolf River	3	3	
Hibernal	3	3	
St. Lawrence	2	2	
Talman Sweet	2	2	
Yellow Transparent	2	2	
Pewaukee	2	2	
Total	214	203	11

PEARS.

	SET	ALIVE	DEAD
Giffard	2	2	
Frederick Clapp	2	2	
Flemish Beauty	2	2	
Tyson	2	2	
Winter Nelis	2	2	
Anjou	2	2	
Boussock	2	2	
Doyenne d Ete	4	4	
Augouleme	2	2	
Sheldon	2	2	
Seckel	2	2	
Lawrence	2	2	
Total	26	26	

CRAB APPLES.

	SET	ALIVE	DEAD
Pride of Minneapolis	3	3	
Whitney	5	5	
Hislop	2	2	
Transcendent	5	5	
Greenwood	3	3	
Bailey's Crimson	3	3	
Martha	3	3	
Virginia	3	3	
Orange	3	3	
Early Strawberry	3	3	
Total	33	33	

CHERRY TREES.

	SET	ALIVE	DEAD
Yellow Glass	5	4	1
Orel No. 24	5	5	
Slanka	5	5	
Amarilla	2	2	
Lutovka	5	4	1
Griotte du Nord	5	4	1
Bessarabian	5	3	2
Black Tartarian	3	1	2
Griotte Precose	5	4	1
King's Morello	5	4	1
Royal Duke	2	2	
Wragg	3	1	2
May Duke	2	0	2
Ostheim	3	1	2
Windsor	1	0	1
Tradescant	2	2	
Montmorency	2	2	
E. Richmond	2	2	
Total	62	46	16

APRICOTS.

	SET	ALIVE	DEAD
Gibb	3	2	1
Alexandria	3	2	1
Budd	3	3	
Total	9	7	2

PRUNES.

	SET	ALIVE	DEAD
George Glass	3	2	1
Hungarian	15	15	
Communia	8	7	1
Total	26	24	2

PLUMS.

	SET	ALIVE	DEAD
Tatge	3	3	
Charles Downing	2	2	
Spanish King	1	1	
Riga No. 113	5	2	3
Wilson	1	1	
Moldovka	5	5	
Ogon	5	5	
Wyant	2	2	
F. Garden	3	3	
Milton	3	3	
Yellow Veronesch	5	5	
Hammer	3	3	
Maquoqueta	5	4	1
Yellow Glass	7	6	1
Wild Goose	3	3	
Wolf	3	2	1
Rollingstone	3	3	
McLaughlin	2	2	
Desota	8	8	
Weaver	3	3	
Hawkeye	3	1	2
Smith's Orleans	2		2
Lombard	2	2	
Green Gage	3	3	
Coe's Golden Drop	2	2	
Bavay's Green Gage	2	2	
Fellemburg	2	1	1
Peter's Y. Gage	2	2	
Total	90	79	11

RECAPITULATION.

	SET	ALIVE	DEAD
Apples	214	203	11
Crab Apples	33	33	
Pears	26	26	
Cherries	62	46	16
Apricots	9	7	2
Prunes	26	24	2
Plums	90	79	11
Total	460	418	42

Set in spring 1895	442
Set in spring 1896	18
Total	460

Dead of spring 1895 planting	41
Dead of spring 1896 planting	1
Total	42

Twenty-six varieties of apples are Russian, obtained from Prof. J. L. Budd, Horticulturist, of the Agricultural College of Ames, Iowa. These were one and two years from the graft, and while they comprise about one-half of the apples planted, the loss is much heavier relatively with these than with American apples, the loss among Russians being eight while those dead of other sorts amount to three in number.

The list set is an extended one and was planted not only as a test of hardiness, but to have growing in Montana an orchard, the varieties of which are true to name. The necessity of this is owing to the many instances that have come to our notice, of trees that have been sold and delivered under fraudulent names.

NURSERY GROWN TREES.

For the purpose of determining desirable sorts for Montana, and of growing sorts true to name, as well as to test the quality of this state for producing nursery grown trees, there was set in the spring of '96, 10,100 sort grafts, 100 each of 101 sorts, as follows:

American Summer Pearman,
Canada Red June,
Duchesse,
Early Harvest,
Early Strawberry,
Early Red,
Early Pennock,
Keswick Codlin,
Red Astrachan,

Gano,
Gravenstein,
Huntsman,
Iowa Blush,
Isham's Sweet,
Hersey Sweet
Jannett,
Charlottenhaler,
King of Tompkin's Co.

Chenango Strawberry,
Yellow Transparent,
Autumn Strawberry,
Alexander,
Cole's Quince,
Fameuse.
Flora Belle,
Haas,
Longfield,
Maiden Blush,
Leibe,
Rolfe,
Ramsdell Sweet,
Red Bietigheimer,
Wealthy,
Hibernal,
Hubbard Nonsuch,
Arkansas Beauty,
Arkansas Black,
Allen's Choice,
Belle de Boskoop,
Bailey's Sweet,
Black-twig,
Carthouse,
Clayton,
Delaware,
Red Winter,
Stump The World,
Spitzenburg Esophus,
Twenty Ounce,
Utter's Large Red,
Yellow Belleflower,
York Imperial,
Yellow Newton Pippin,
Minkler,
Florence,
Gideon,
Lawver,
Lansingburg,
Missouri Pippin,
Milam,
Mann,
McMahon's White.
Northern Spy,
N. W. Greening,
Perry Russett,
Plums Cider,
Price's Sweet,
Pewaukee,
Pumpkin Sweet,
Roxbury Russett,
Rome Beauty,
Roman Stem,
Rubicon,
Rhode Island Greening,
Ripston Pippin,
Salome,
Okabena,
Shockley,
Scott's Winter,
White Winter Pearman,
Smith's Cider,
Stark,
Grime's Golden Pippin,
Milton,
Montreal Beauty,
Walbridge,
Willow Twig,
Wine Sap,
Winter Sweet Paradise,
Wolf River,
Talman Sweet,
Lowell,
Sweet June,

Golden Beauty,
Hugh's Virginia,
Martha,
Queen's Choice Cluster,
Minnesota,
Tetofsky,
Transcendent,
Van Wyck,
White Arctic,
Whitney No. 20,
Lady Elgin,
Seek-No-Farther,
James Sweet,
Rambo,
Ben Davis,
Red June,
Fameuse,
Dominie,
Smokehouse,
Baldwin,
Alaska.

These grafts were made in March, 1896, were wound with waxed cotton thread instead of waxed paper, and were packed for shipment in moss. The result of this method of grafting, while practiced by many large nurserymen, is not the best to secure an even stand of grafts. Grafts made in this manner in December and packed away in a suitable cellar, will between that time and the spring following undergo what is termed a "callousing" process, namely, a healing of the cut surfaces of both root and cion. Grafts that are bound with waxed paper are less liable to fungous attacks, or to decay from moisture penetrating between graft and cion, or to wither up from a lack of moisture when planted out, than is the case when the graft is freshly made, and set before nature has time and opportunity to heal the fresh wounds. 45 per cent of the root grafts set in spring of '96 grew; these have made fair growth.

There are growing on our test grounds, certain varieties of apple trees and grafts, that have been secured from four different firms, thus lessening the likelihood of error in nomenclature of these varieties, one lot acting as a check upon others. Many of the trees grown from these grafts will be planted in the experiment orchards, and the surplus will be sold in limited quantities at such prices as will cover cost of production, not with the idea of entering into competition with Montana nurserymen, but rather with the hope and expectation of being helpful to them in promoting and increasing interest in the work. The production of fruit in Montana has been shown to be an industry worthy of fostering care, and the best effort of the Station will be exercised in solving questions of the utmost importance to those, who as yet, are practically inexperienced in the work.

In the future, root grafts that are to be planted on this Station, will be made here, adding to the present selection, such varieties of fruit, as appear to be promising to the state. This list will be necessarily a large one, inasmuch, as there is no state in the union that has so varied conditions for fruit growth. There are sections of the State in which any or all of the apples, crabs, plums, prunes, peaches, apricots, cherries and pears that are grown in the Pacific States can be successfully grown, while again, there are in the Northeastern part of the state, the lower Missouri Valley, and in some of the high lying valleys, large areas in which only the very hardiest of the apples and crabs can be grown. Tender varieties of the various fruits can be more successfully grown, as nursery trees, than can be expected to stand as orchard trees, hence it may be expected that the conditions existing in this valley are favorable to an experiment nursery.

STRAWBERRY CULTURE.

The land selected for strawberry beds was virgin soil. It was broken up in August, 1894, worked down from the sod as well as might be, with various harrows, disks, etc., and was covered with water for perhaps five weeks. The spring following it again received good cultivation, leaving it in as good shape for the reception of plants as was possible under the circumstances. Without a full appreciation of the necessity of having a perfect grade for the best service of water, and believing it to be naturally sufficiently level, no attempt was made to bring it to grade. The necessity for this was seen at a later date, in the failure to obtain a perfect stand in several of the varieties that were set. This tract of land is 27 rods in length, 24 feet in width, rows running north and south four feet apart. The plants were set 18 inches apart in the rows. In selecting plants for the experimental plat beds, such varieties were purchased as are known to be popular plants in the leading strawberry sections of the Union. To these were added those that are giving the most general promise. These were set indiscriminately, without reference to sex or bloom period, it being thought wiser to first secure data on our own grounds and then reset to the best general advantage with those plants giving the most general promise.

The strawberry offers great inducements to propagators, because unlike other fruits, it comes to bearing very early. The result of this is that there are countless new kinds put upon the market that possess only local value and are exploited at large expense for propagation and advertising. The great majority of introduced strawberries are absolutely worthless for general cultivation. It is estimated that more than 1,000 new strawberries have been introduced within the past quarter of a century, many of which have long since been forgotten. There are but few of the old popular standbys that have held a place in the general lists, and some of these have serious faults. Various qualities must exist to constitute a perfect berry. These are flavor, color, size, texture, vigor of plant, season and productiveness.

Perhaps the most important of these qualities to the market berry grower are size, texture of fruit, and productiveness. The fruit must commend itself to the purchaser, by its general appearance. Size and firmness have more to do with this than any other conditions. A large soft berry reaches the consumer (who as a rule is more than 100 miles from the production point) usually in a crushed condition, and is practically valueless as a wholesome article of food, and again, unless the plants bear abundantly the grower markets them at a loss, as the expense attendant upon strawberry growing is large and unlike other fruit crops can not be harvested at one's leisure. To one growing for the home table, the flavor, vigor of plant and productiveness are more important considerations, as the home table is more likely to be critical than the majority of purchasers.

Locally the season for blooming and fruiting is an important consideration. The altitude of the Station (4,793 feet) precludes competition with the lower lying, warmer valleys. Careful study has therefore been made of these points, with the object of determining those varieties that bloom after the usual period for late general spring frosts. The bloom period was quite successfully delayed for a full week after unprotected beds were in full bloom, by delaying the removal of mulching with which the strawberry beds had been covered. The mulch was mainly well rotted straw taken from the butt of a straw pile four years old and was applied January 29, '96, and was removed from the plants into the vacant spaces between the rows on April 25, '96, and was not finally removed from the beds until the plants had completed full fruiting. It was noted that irrigation was much more successfully performed while the half rotted straw remained between the rows, as rapid evaporation of moisture and washing of the soil were avoided by the mulch.

The value of mulch as protection to plants is shown by the fact that a critical examination of the bed after the mulching was removed, showed but one plant to have died from winter killing.

The parent plants were purchased from W. F. Allen, Jr., of Salisbury, Md., and were ordered to arrive April 20, 1895. A combination of circumstances prevented setting the plants until 30 days after they were dug, and that a fair stand was procured is ample testimonial first to the quality of the plants and the way in which they were packed, and second, to the desirability of a cool, well ventilated cellar on the farm. In such a cellar they were kept in perfect order, by removing from the packing cases, moistening the roots, and piling together in two shallow rows, roots to the center, these being covered with sphagnum (cranberry moss) until they were planted. As rapidly as a row of plants was set it was irrigated and notwithstanding the spring was dry, cold and windy a good stand resulted. Twenty-five plants of a kind were set. The following table shows variety, date of first bloom, time of first fruit, also yield in pounds and ounces, from twenty-five plants:

STRAWBERRY LIST.

Variety......	Sex..........	Date First Bloom......	First Ripe Fruit......	Am't Fruit From 25 Plants......
Michel's Early.......	Staminate	June 7	July 4	2 ℔ 11 oz
Crescent.............	Pistillate	June 9	July 5	13 ℔ 8 oz
Beder Wood.........	Staminate	June 10	July 5	17 ℔ 11 oz
Lovett...............	Staminate	June 13	July 5	22 ℔ 1 oz
Warfield.............	Pistillate	June 9	July 5	16 ℔ 14 oz
Van Deman.........	Staminate	June 8	July 5	5 ℔ 15 oz
Ivanhoe..............	Staminate	June 14	July 5	16 ℔ 7 oz
Paris King...........	Staminate	June 12	July 5	17 ℔ 9 oz
Robinson.............	Staminate	June 12	July 6	14 ℔ 7 oz
Stayman No. 1......	Pistillate	June 12	July 6	21 ℔ 8 oz
Dayton...............	Staminate	June 8	July 6	5 ℔ 6 oz
Haverland...........	Pistillate	June 8	July 6	3 ℔ 15 oz
Beverly.............	Staminate	June 14	July 7	11 ℔ 5 oz
Bisel.................	Pistillate	June 14	July 6	27 ℔ 11 oz
Stevens..............	Staminate	June 12	July 6	1 ℔ 14 oz
Bubach No. 5........	Pistillate	June 15	July 8	7 ℔ 5 oz
Edgar Queen........	Pistillate	June 14	July 8	10 ℔ 13 oz
Sandoval............	Staminate	June 16	July 13	4 ℔ 3 oz
Hoffman No. 1......	Staminate	June 14	July 8	4 ℔ 6 oz
Brandywine.........	Staminate	June 21	July 17	10 berries
Columbian..........	Staminate	June 15	July 10	3 ℔ 14 oz
Leader..............	Staminate	June 9	July 8	7 ℔ 11 oz
Cyclone.............	Staminate	June 13	July 8	22 ℔ 7 oz
Tennessee Prolific...	Staminate	June 9	July 8	16 ℔ 6 oz
Crawford...........	Staminate	June 15	July 8	6 ℔ 4 oz
Meek's Early........	Staminate	June 16	July 8	7 oz
Gandy Belle.........	Staminate	June 12	July 9	19 ℔ 7 oz
Arrow..............	Pistillate	June 12	July 9	5 ℔
Great Pacific........	Pistillate	June 15	July 9	2 ℔ 10 oz
Enormous...........	Pistillate	June 16	July 9	15 ℔
Mrs. Cleveland......	Pistillate	June 15	July 9	8 ℔ 6 oz
Wilson's Albany.....	Staminate	June 12	July 9	13 oz
Enhance............	Staminate	June 9	July 9	24 ℔ 2 oz
Barton's Eclipse....	Pistillate	June 9	July 9	12 ℔ 5 oz
Timbrell............	Pistillate	June 8	July 15	4 ℔ 7 oz
Chairs Seedling......	Staminate	June 15	July 10	2 ℔ 8 oz
General Putnam.....	Pistillate	June 9	July 10	4 ℔ 1 oz

STRAWBERRY LIST.--Continued.

Variety	Sex	Date First Bloom	First Ripe Fruit	Am't Fruit From 25 Plants
Governor Hoard	Staminate	June 12	July 10	12 ℔ 6 oz
Victor Hugo	Staminate	June 12	July 10	4 ℔ 5 oz
Shuster's Gem	Pistillate	June 12	July 10	5 ℔ 13 oz
Splendid	Staminate	June 14	July 10	22 ℔ 9 oz
Swindle	Pistillate	June 12	July 9	13 ℔ 2 oz
Rio	Staminate	June 15	July 10	1 ℔ 2 oz
E. P. Roe	Staminate	June 12	July 12	5 ℔ 6 oz
Princess	Pistillate	June 13	July 11	9 ℔ 4 oz
Parker Earle	Staminate	June 12	July 11	3 ℔ 6 oz
Klickitat	Pistillate	June 11	July 10	13 ℔ 15 oz
Gillespie	Staminate	June 13	July 11	2 ℔ 1 oz
Greenville	Pistillate	June 12	July 11	8 ℔ 3 oz
Belmont	Staminate	June 14	July 11	7 ℔ 13 oz
Eureka	Pistillate	June 12	July 11	6 ℔ 12 oz
Sharpless	Staminate	June 13	July 11	6 ℔ 5 oz
Muskingum	Staminate	June 15	July 11	3 ℔ 13 oz
Princeton Chief	Pistillate	June 15	July 12	4 ℔ 8 oz
Jay Gould	Pistillate	June 19	July 13	1 ℔ 13 oz
Gandy	Staminate	June 19	July 13	4 ℔ 10 oz
Banquet	Staminate	June 16	July 13	2 ℔ 10 oz
Belle	Staminate	June 16	July 15	8 ℔ 4 oz

The strawberry has been claimed to possess strong local characteristics, and frequently is dependent upon peculiar local conditions for success. This season's experiments prove the truth of this statement. That a strawberry achieves a great reputation in a certain locality, is no reason that it may be expected to succeed equally as well elsewhere, and emphasizes the importance of experimentation, before one plants largely of any of the untried sorts.

It is proposed to continue strawberry experiments, making careful selections of sorts that have simultaneous bloom and fruit periods, of planting such contiguous to each other, so that perfect pollination may ensue.

Hay fever is now conceded to be caused by the irritating influence of the pollen of certain plants upon the sensitive mucuous membranes of the head; and while the pollen of the strawberry plant may not be so readily transmissible as that of other plants, it is important to determine the proper percentage of staminate sorts that should be set with pistillate sorts. It is well known to nurserymen that pistillate sorts properly fertilized are much more productive than staminate sorts when set alone.

The direction of prevailing winds will also be noted during the fertilizing period, to settle the distance that pollen is transferred, also whether pollination may be successfully accomplished without the offices of insects.

In observations upon new varieties it is thought to be advisable to consider the character of the fruit and leaf stems of the plants, also of the general character of the foliage, as the value of a strawberry plant grown under irrigation is largely dependent upon the ability of the plant to hold its foliage and fruit well up from the ground, and thus avoid soiling the fruit by contact with the ground made muddy by irrigation and also leaf scald, resulting from foliage being immersed in water.

When practicable, water was applied to the beds at night, this in great measure preventing sun scald. The character of the soil in which the plants are, is such as to dry out rapidly when the water is diverted from the plants.

NOTES UPON VARIETIES.

MICHELS' EARLY.—In best bloom June 15th, rank growth of foliage, poor bloomer, running freely June 26th. This is a standard variety in the Mississippi valley, but is practically worthless upon these grounds.

CRESCENT.—In full bloom June 26th, a rank grower, running freely on same date, fruit stems delicate, foliage dense, low grower, was not properly fertilized, but produced sufficiently well to be in the class yielding over one-half pound to the plant.

BEDER WOOD.—In full bloom June 20th, runners starting on same date, luxuriant foliage, leaf and fruit stalks strong and erect, a liberal bearer of good sized fruit, of fair quality, a desirable variety for home use.

LOVETT.—In full bloom June 26th, medium foliage, low growth, an excellent bearer, among the best.

WARFIELD.—This is a leading pistillate variety in the Mississippi Valley. Owing to the condition of ground when set, a good stand was not secured and vacancies were filled with new plants in the spring of 1896. New plants were forming June 26th, growth medium.

VAN DEMAN.—In full bloom June 26th, a weak growth of foliage, a very moderate bloomer and fruiter.

IVANHOE.—In full bloom June 24th, a vigorous grower, leaf and fruit stalks erect and vigorous, a free and abundant bloomer, no new plants set until July, among the most productive bearers, and the fruit is of exceptionally good quality, both as to size and flavor.

PARIS KING.—In full bloom June 26th, a strong grower, but foliage close to ground, one of the promising varieties.

ROBINSON.—Setting new plants and in heighth of bloom June 26th, a good producer, fruit below medium size but of good quality.

STAYMAN NO. 1.—A medium grower, strong, vigorous fruit and leaf stems, in full bloom June 26th, a variety that will prove to be profitable.

DAYTON.—A weak development of foliage, thin and close to the ground, offers but little promise.

HAVERLAND.—An old popular variety, a medium grower, was not sufficiently fertilized to give it a fair test, quality and size of fruit above medium, in full bloom June 26th.

BEVERLY.—In full bloom June 23d, runners not developed until August, quality and quantity of fruit sufficient to warrant trial.

BISEL.—In full bloom June 24th, strong, vigorous growth of foliage, leaf and fruit stem development of medium height, new plants setting in August; the heaviest yielder of good sized and firm fruit, and the most promising, a pistillate variety, and when set with proper pollenizing variety, will make a choice market variety.

STEVENS.—Good foliage development, but worthless on these grounds.

EDGAR QUEEN.—In full bloom June 24th, of feeble growth, worthy of trial.

SANDOVAL.—A strong, vigorous development of plant, but gives little promise of profitable fruiting.

BUBACH NO. 5.—A standard market berry in the east, but comparatively valueless on these grounds.

BRANDY WINE.—A vigorous growth of foliage, of deep, rich color, new plants developing August 1st; a poor bloomer and fruiter, a good illustration of the perversity of the strawberry. This is a leading sort, highly advertised in the east, but it averaged less than half a berry to the plant, on these grounds.

HOFFMAN NO. 1.—Original plants did poorly, stand made from re-set plants spring of 1896, late both in bloom period and in development of new plants, an indifferent bearer.

COLUMBIAN.—A good development of foliage, leaf and fruit stems of strong and upright habit, an indifferent bearer.

LEADER.—In full bloom June 17th, setting new plants June 26th, foliage light, considered worthy of farther trial.

CYCLONE.—A plant of excellent promise, abnormally strong, thick fruit-stems, late in development of new plants; third best berry tested, as to quantity and quality.

TENNESSEE PROLIFIC.—In full bloom June 26th, foliage thin and sparse, fruit stems strong and vigorous, an excellent variety.

CRAWFORD.—Unfavorably located in setting, poor stand, new plants re-set spring of 1896, worthy of trial.

MEEK'S EARLY.—Practically worthless.

GANDY BELL.—In full bloom June 26th, not up to average in foliage, but among the best of the fruiters.

ARROW.—Indifferent stand, re-set with new plants, spring of 1896, a vigorous grower, but poor fruiter.

Great Pacific.—Rank growth of foliage and new plants, but extremely indifferent in fruiting.

Enormous.—Properly named, both as to plant development and size of fruit; with proper fertilization this variety would rank with the best of yielders.

Mrs. Cleveland.—A producer of rank foliage, but does not give sufficient fruit to warrant setting.

Wilson Albany.—Unfortunate in location but a small per cent of plants grew, bed re-set spring of 1896, but new plants were weak and small; began to form new plants July 1st. This is one of the first improved strawberries, and was a leader for many years. Plants under this name are succeeding admirably in many parts of Montana. Will receive farther trial.

Enhance.—A perfect bloomer; in full bloom June 25th, foliage rank, large, compact fruit stems; ranking second best in yield; quality of fruit not so choice as some others, but considering quantity, size, firmness, shape and color of fruit, it is the best market variety on these grounds.

Barton's Eclipse.—In full bloom June 17th, strong, vigorous development of foliage, fruit of good size, but of medium production, worthy of trial.

Timbrel.—Another plant that has been highly lauded in eastern beds, but has failed to justify expectations under test on these grounds.

Chair's Seedling.—Did not secure a good stand, re-set spring of 1896, bloomed profusely but did not yield fruit in quantity to warrant belief in its value.

General Putnam.—A medium growth of foliage, blooms sparse and unsatisfactory in yield.

Governor Hoard.—In full bloom June 21st, foliage moderate, new plants forming June 26th, a very free bloomer, gives much promise, worthy of careful trial.

Victor Hugo.—A rank, vigorous plant, gave good promise in early part of season, expectations not realized in fruit yield.

SHUSTER GEM.—Many original plants failed first season, re-set spring '96, a strong grower, worthy of farther trial.

SPLENDID.—This variety in performance stands toward the head, a perfect bloomer, strong, vigorous growth of foliage, with abnormally stout fruit stems, well worthy of propagation.

SWINDLE.—Attracted much attention from visitors, by its wealth of bloom and very sparse development of foliage. Evidently it requires special treatment of soil to give more size and development of fruit which was much under size. Its farther performance will be closely studied.

RIO.—A strong and vigorous grower, but without sufficient bloom or fruit development to render of value.

E. P. ROE.—Has a good record elsewhere; here it made but feeble growth, with fair proportion of blooms. No runners were formed until August; it calls for special enriching of the soil.

PRINCESS.—A poor stand from original setting, re-set spring of 1896; weak foliage development, it bore sufficiently well to merit farther test.

PARKER EARLE.—Another much advertised sort, that does not justify expectations on these grounds; made late and feeble growth of plants.

KLICKITIA.—One of the strongest and most vigorous plants in the test, very large upright leaf and fruit stem, fruit above medium size, inferior in flavor, with poor coloring; of sufficient merit to warrant farther test.

GILLESPIE.—Practically worthless under test.

GREENVILLE.—In full bloom June 26th, an imperfect bloomer; a variety that has been extensively catalogued as being very desirable, a prime favorite in Ohio. Its performance on these grounds has been disappointing.

BELMONT.—Of medium development of foliage, a popular eastern variety, fruit of good size and quality, not satisfactory as far as tested, but will give farther trial.

Eureka.—A moderate grower, test not satisfactory owing to half the row having been re-set spring 1896.

Sharpless.—This variety in the east divides with the Jesse, the honor of being the ideal home berry, the fruit being large and rich in flavor. The test was not satisfactory, owing to poor stand and the bed having been re-set spring 1896; will be tested under more favorable conditions.

Muskingum.—In full bloom June 26th; a weak grower, new plants developing in August, of no special merit.

Princeton Chief.—Of moderate habit of growth, a shy bloomer, with unsatisfactory development.

Jay Gould.—Desirable for everything but fruit, yielding comparatively none under this test.

Gandy.—An extensively advertised late variety, perhaps the latest in this test, worthy of farther trial.

Banquet.—A poor grower and a scant fruiter.

Belle.—A novelty from the shape and character of the fruit, which much resembles the old-fashioned bell pepper very light in color, moderately firm, an ideal home berry and one that would command the highest price if it could be placed upon the market in good condition; of low, compact growth, very strong, vigorous fruit stems, a medium bloomer, a variety well worthy of extended test.

BEST YIELDERS.

In determining yield, no account is made of fruit borne on new plants produced from the original plants, all being treated alike, the comparison of fruit per plant is fair and just.

It is thought desirable to call attention to the sorts that have averaged above one-half pound of fruit to the plant; to extend plantings of these sorts, properly grouped with reference to character of bloom, (staminate and pistillate), also time of bloom—that is to say, properly alternating perfect and imperfect bloomers and also those sorts that have same period for pollen formation. It is expected under such conditions, others being equal, to secure yields from these sorts that will average more than a pound of fruit to the plant:

Variety........	No. Plants.....	Pounds........	Ounces........
Bisel	25	27	11
Enhance	25	24	2
Splendid	25	22	9
Cyclone	25	22	7
Lovett	25	22	1
Stayman	25	21	8
Gandy Bell	25	19	7
Beder Wood	25	17	11
Paris King	25	17	9
Warfield	25	16	14
Ivanhoe	25	16	7
Tennessee Prolific	25	16	6
Enormous	25	15	
Robinson	25	14	7
Klickitia	25	13	15
Crescent	25	13	8
Swindle	25	13	2
Governor Hoard	25	12	6
Barton's Eclipse	25	12	5

S. M. EMERY,
HORTICULTURIST.

REPORT OF THE CHEMIST.

BOZEMAN, MONT., September 1, 1896.

HON. S. M. EMERY, Director,
Montana Agricultural Experiment Station,
Bozeman, Montana:

DEAR SIR:—The work of the Chemical division has been, and of necessity always will be, to a very large extent, routine, in conjunction with the other divisions, particularly the Agricultural. The collection of the analytical data, while it takes much time and makes an apparently poor showing for the energy expended, is of inestimable value, and will afford an invaluable source of reference for our future investigations.

The most important investigation undertaken by this division is on the effects of unusual quantities of mineral salts in solution upon plant life and growth.

This condition exists in the irrigation waters of many of our important agricultural valleys, on account of the location of silver-milling plants on many of the streams.

While this investigation is not yet completed, sufficient progress has been made to show that very interesting, and in some cases, entirely unexpected results will be obtained. It is safe to say now, from the standpoint of injurious effects upon crops, that not nearly so serious an effect as might be anticipated from the strong solution running to waste from the mills will be found, and that with proper precautions on the part of the miner and the rancher these solutions can be used with safety.

The principal constituents of these waters are the sulphate and chloride of sodium, which when used in proper quantities are, instead of being injurious, highly beneficial to plant growth; on the other hand, it is well known that a strong brine will kill grass and other plants. The purpose of these investigations is to determine if the irrigation waters become sufficiently strong in soluble salts to produce this latter effect. The details and conclusions will appear in a special bulletin as soon as further experiments are completed.

Our inadequate quarters render the carrying on of both the work of investigation and analysis extremely difficult. We are very much crowded for room, and knowing that we are to occupy these rooms for a short time only, we have not felt that we would be justified in putting in here many inexpensive but labor-saving devices which can be placed in the new laboratory to great advantage. The most needed of these is a gas machine, and a tank for securing constant water pressure.

Much of our time has been employed in planning the arrangement of rooms in the new building, and details of desks and other laboratory furniture. There is no doubt that our capacity for analytical work will be more than doubled when we are able to occupy our new rooms.

In the spring a large number of packages of sugar-beet seed were sent to farmers in all parts of the state. We hope, by co-operation of the farmers in the raising of beets, to learn what portions of the state are best adapted to sugar-beet culture. Analyses of samples of sugar-beets raised here show that in many parts of the state we can raise beets carrying a percentage of sugar far above the average. A bulletin will be issued soon after the last of the samples have been analyzed.

An investigation of the sanitary condition of our farm wells is about completed, and the result will soon be published.

The study of the composition of our irrigation waters promises very interesting results. Particularly is this the case in the Gallatin valley, where the waters supplying one side of the valley come mainly from limestones, while on the other side the rocks are igneous. Some analytical data is already in hand relating to this matter, but the study will have to extend over several seasons and should involve not only the origin and composition of the waters, but also of the soil.

We have co-operated with the association of Official Agricultural Chemists to the fullest extent in our power, in its effort to obtain better analytical methods, but most of this work has remained incomplete because of our inability to control our time in the face of the required routine work. The press of work in both of these lines comes at the same time.

A study of methods for the determination of the nitrogen-free extract of plants with more particular reference to the determination of the carbohydrates by estimating the amount of copper reduced by the hydrolyzed starch by means of ammonium ferric sulphate and potassium permanganate, has been in progress for two years, and important results concerning methods of manipulation have already been obtained.

The assistance rendered by Mr. Cobleigh has been of very great service to me. He has done a very large share of the analytical work, and I have the utmost confidence in his results.

Yours very truly,

FRANK W. TRAPHAGEN, Ph. D., F. C. S.,
Chemist.

THE SPAYING OF MARES.

The emasculation of domestic animals, rendering them devoid of sexual power and instinct, has been freely practiced for centuries, the objects aimed at being chiefly:

First—Rendering the castrated animal more docile and subject to the control of man.

Second—Increasing the quantity and quality of food products furnished by the animal—meat and milk.

Third—Controlling the quantity and quality of animal reproduction.

The castration of both male and female animals, except the mare, has been so universally practiced that its economic value goes without question, but in this one instance there seems to be no definite data upon which to base an opinion. Mares have been castrated to a considerable degree at times in continental Europe and the practice is even said to have been interdicted by royal orders in some instances, presumably to avoid a scarcity of horses. The results of the castration of mares do not appear to have been extensively recorded and little literature upon the subject is available. The earlier method of operating was like that upon smaller animals, by making an incision in the flank and removing the ovaries through this. Such a method, with the vague notions of surgery, constituted a very grave surgical operation. The opening in the flank must be large enough to admit the operator's hand, while the cause of infection and inflammation of wounds being unknown, no effective measures were taken to prevent these consequences.

A simpler and safer method for operating on the cow and mare was more recently introduced by Charlier, in which the ovaries were removed by means of an incision through the vagina, obviating an external wound, and decreasing very much the extent of injury to the tissues.

Following this improvement came the discoveries of Pasteur and others, showing that inflammation of wounds with suppuration, (formation of pus) ulceration, mortification and other dangerous complications are due to the introduction, in practically all cases, of some form of disease-producing bacteria, or other low form of life, to which Lister and others responded by showing that certain methods of procedure in surgical operations prevented the lodgment of germs in the wound, or had they gained admission to the wound, certain substances (antiseptics) could be relied upon to destroy the offending organisms, the result of which has been a complete revolution in the science of surgery.

Subsequent to the introduction of Charlier's plan of operating, and antiseptic methods in surgery, the spaying of mares, so far as recorded, has been quite limited and restricted almost wholly to two classes of cases: First, disease of the ovaries, and second, viciousness of the animal. In both classes, the operation has proven successful in a reasonable measure.

The surplus of horses in Montana and other western states, their present low value and general surroundings seemed favorable for testing on a moderate scale the economic value of castration of mares, and the subject was accordingly taken up under favorable auspices only to be interrupted at its very inception by my removal from the state. The objects which it was hoped to obtain were:

First—Increased docility of the animal at all times.

Second—The prevention of œstrum ("heat" or "horsing") in which state, mares are excitable, not infrequently vicious and uncontrollable, and are at best weakened and less capable of performing their regular work, besides the simply repugnant features of the period of "heat."

Third—The affording of a convenient and safe mode for the control or prevention of breeding.

The operation makes in effect a gelding and it is believed that the castrated mare is preferable to the farmer, the mare being generally of finer form, being free from the annoying accumulations of filth observed in the sheath of the penis in the gelding, being cleaner in the stall, since she voids the urine behind her bedding and consequently does not become so much soiled in lying down.

With the above objects in view, and enough mares offered to answer for a preliminary test, the necessary instruments for the operation were secured, consisting of a force pump, similar essentially to an ordinary garden pump, a vaginal dilator, or tensor, such as is used in the vaginal spaying of cows, a concealed knife, and a special ecraseur of the Chassaignac, or ratchet pattern, 22 inches long and with the ratchets so guarded that the instrument could be readily worked within the vagina.

Sixteen mares were furnished for the operation by Mr. Geo. H. Lyon, Lyon, Montana, and six by Mr. I. K. Wisner, Bozeman, Montana. Through error in procedure, two animals were not spayed, reducing the actual total to twenty. The first operations were performed on the mares belonging to Mr. Lyon, consisting of one very weak, thin, overworked and starved three-year-old mongrel mare, procured but a day or two before the operation. The others were grade French draft mares aged four to six years, four of the number broken to the saddle, or harness, eleven were range mares which had been halter broken as weanlings, but had not been handled subsequently.

All these latter were in prime condition and presumably not in foal, although in operating it was found that one was well advanced in pregnancy.

One of the broken mares had at times been vicious, balking and kicking at unexpected times, probably at periods of "heat."

None of the animals were being fed grain, and except the five broken animals none had ever been fed on grain. The five broken animals were taken from the range and placed in a corral without food on the evening of June 24th, 1896, and the unbroken mares were corraled on the following morning, after a sharp drive of ten miles from their usual feeding grounds. The broken and five of the unbroken mares were operated upon on the evening of June 25th and the remaining six on the following morning.

The mares were led into a chute used for branding cattle, tied by a halter to a post in front, bars placed beneath the chest and flank to prevent the animal from lying down, and the tail drawn directly upwards and made fast to a crossbeam. The hind feet were roped and secured forward to a post to prevent kicking.

Two or three quarts of warm water were thrown into the rectum and an assistant then introduced his hand and removed any feces present, except in one case to which we will refer later. The external parts were then washed with a solution of corrosive sublimate 1 to 5,000 or 6,000, two or three quarts injected into the vagina, the hands carefully washed and instruments submerged in the same. (Other disinfectant should have been used for this purpose to save corrosion.) The vaginal tensor was then introduced with the hand, the prolongation fixed in the mouth of the womb, the walls of the vagina rendered tense, the concealed knife carried into the vagina, opened, and an incision about one inch long made at the end of the vagina just above the mouth of the womb, after which the knife was removed.

The hand being again brought into the vagina one or two fingers were pushed through the incision, followed by the other fingers of the hand in cone shape, the walls readily giving way and the entire hand was pushed into the abdominal cavity. The ecraseur was then introduced, guarded by the hand. By following the womb, lying immediately beneath the incision, the cornua or horns were soon reached, at a distance of six to ten inches from the incision, leading from the womb at almost right angles, and soon ending to be continued by the ligament of attachment, in which the ovary was readily and unmistakably found at a distance of two to four inches from the blunt end of the cornu. The chain of the ecraseur was then placed over the ovary, and holding the instrument and ovary securely with one hand, the instrument was tightened with the other, the ovary quickly crushed off and along with the ecraseur carried out. The crushing off of the ovary was practically the only step in which there was evidence of any considerable degree of pain, and this was not nearly so severe, judging by the struggles of the animal, as is seen in the castration of horses. The second ovary was removed in the same manner. Very little bleeding followed the operation. The animals were released without further procedure, and all confined in a meadow convenient for obobservation.

They were inspected twice daily on June 26th, 27th, 28th and 29th; as closely as practicable with wild mares.

There was some slight straining shown by most of the mares immediately after their release, and nearly all were noted lying down quietly. None of them, at any time observed, showed any signs of severe pain, not nearly so severe as is commonly seen, after the castration of stallions.

The three-year-old mare which, as before stated, was in poor condition, in fact not fit to undergo an operation, seemed stiff and dull, but continued to graze daily. No discharge from the vagina was observed and no symptoms appeared, to create alarm, and by the 29th she seemed somewhat improved. She was the first animal operated upon in the number, and my first operation on a mare, and in addition to her unfit condition the emptying of her rectum was overlooked, presuming that without grain the feces would be soft and pultaceous, but instead the rectum proved quite full of rather firm fecal matter and in cutting upwards towards it; and the vagina of the mare being *very much* thinner than that of the cow, the cut was made too deep and almost penetrated the rectum, a complication which probably did much to interfere with her recovery.

Of the other mares, none appeared to noticeably suffer, except that one animal lay down much of the time, but when approached, would jump to her feet, trot quickly away and commence to graze. Two or three others showed slight stiffness for 24 to 48 hours, but not sufficient to lead the ordinary observer to note anything amiss. When approached they all trotted briskly away, all grazed regularly, and apparently did not gaunt or lose weight.

It was expected that the pregnant mare would abort, but she seemed to be still carrying her foal safely at the date of our last observation.

We have already intimated that owing to an error we failed to spay one of the mares. This error was traceable to an anatomical difference in relation of the vagina to the rectum in the cow and the mare which has not, so far as we can find, been particularly described either by veterinary anatomists or veterinarians who have spayed mares. This difference consists in the extension of the adhesion of the vagina and rectum to a more anterior point than is the case in the cow, and gives as a result a very narrow field for the operation in the former, as compared with the latter. This difference in anatomical relations led to the making of the incision too far posteriorly in the one mare, resulting in our carrying the incision into the rectum instead of the abdomen, and rendering it unsafe to make further attempts at operating at the time, although no ill consequences followed the accident. The same error was again repeated in a young filly among the Wisner mares, with like results.

This evidently indicates that while there may be individual variations, the only safe place to make the incision through the vagina is immediately against the mouth of the womb, especially in young fillies.

In speaking of the method of making the incision, some writers warn against tearing through the peritoneal covering of the vagina, stating that even if repeated attempts are needed, the entire thickness of the vaginal walls must be cut through with the knife, else fatal abcesses are likely to occur about the vagina and rectum. On the contrary, we found it *much* easier to complete the incision by tearing through the peritoneum in the mare than in the cow and had no ill results therefrom, and are forced to believe that the difficulty with those veterinarians having such results was rather due to their want of knowledge of the peculiar anatomical relations of the vagina and rectum above noted, which led them to commit similar errors to those just described.

The operator should also constantly bear in mind that the vaginal walls of the mare are thinner and much more easily cut through or torn than that of the cow.

In a letter dated July 19th the owner reported all mares apparently well except the three-year-old, which was still in bad condition although improving, and on August 3rd all were reported well.

The six mares offered for operation by I. K. Wisner were all well broken animals, were not being fed on grain and were taken directly from the pasture for the operation which was carried out in the same manner as the Lyons mares, without incident except the error in the two-year-old filly, noted with a like error with one of the Lyon mares.

The animals were spayed on the 12th of August and not observed by us later.

On September 8th the owner reported that one mare, with foal at side, had lost much flesh but was apparently well at that date, while the other four had shown the effects of the operation somewhat for four or five days, since which time there seemed nothing amiss.

W. L. WILLIAMS, V. S.

CORROSIVE SUBLIMATE FOR POTATO SCAB.

The effects of potato scab on the tuber are so well known and so easily recognizd that a description of the disease is not here necessary. Both experimenters and potato growers have successfully prevented scab by immersing the seed potatoes, for one and one half hours, in a corrosive sublimate solution, using 2 ounces of the compound to 15 gallons of water. The solution is most readily made by first disoliving the powdered corrosive sublimate in a few gallons of hot water and then adding enough cold water to make the required 15 gallons.

Since the solution corrodes metals, only wooden vessels should be used. A barrel makes a very good receptacle and the potatoes may be conveniently handled by putting them in coarse sacks for the immersion. If not fairly clean, the potatoes should be washed before dipping; after they have been taken from the solution and dried, they may be cut and planted as usual. The corrosive sublimate is very poisonous and must, therefore, be handled with great care.

At the Station last season, scabby seed potatoes treated in the manner indicated above, produced a crop entirely free from the disease. Soil, when once infected with scab, will retain the living germs for a number of years, and it is believed that it may become infected from natural drainage and manure, as well as by a scabby potato crop. For such ground the treatment will not be as effective.

It is always desirable to plant clean seed on soil that is free from the disease; but smooth potatoes, apparently free from scab, may have the germs on their surface if they have been in contact with diseased potatoes. If potatoes are known to be scabby, they should be dug as soon as mature, since the scab continues to grow as long as they are in the ground.

TREATMENT FOR SMUT IN WHEAT, BARLEY AND OATS.

1. The loss occasioned by sowing seed contaminated with smut is very much greater than is usually supposed. The annual damage to the oat crop amounts to fully ten per cent. The injury to the wheat crop is much greater, the loss coming from two sources; a less yield per acre and a lower price per bushel for the damaged grain.

2. Smuts are due to the development of minute parasitic plants which grow within the tissues of the grain.

The disease is spread by spores of smut adhering to the grains before they are sown. This contamination may occur in the field through the wind carrying the spores from adjacent smutted crops, or during the threshing, or by coming in contact with any receptacle that has previously contained smutted grain. In general, experimenters believe there is little danger of contamination through spores in the soil.

3. Stinking smut attacks wheat only. Loose smuts attack all of the small grains, but that of the oat is most damaging.

4. Clean seed, or that effectually treated for smut, will produce a crop free from smut, but an adjoining smutty field may contaminate this grain for next year's crop. The only safeguard is careful treatment before planting.

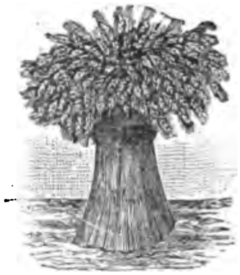
5. The disease in wheat may be entirely prevented by thoroughly wetting the seed in a solution of copper sulphate, (blue vitriol) using eight ounces to a gallon of water, but this will lessen in some degree the vitality of the seed. It may also be effectually prevented, without any damage, by immersion for fifteen minutes in water raised to a temperature of 131° to 135° F.

6. Oat smut may be completely prevented by treating the seed fifteen minutes in water raised to a temperature of

132½° to 135° F. This treatment not only removes the smut but promotes the growth and increases the yield. It may also be prevented without injury to the vitality, by immersing the seed twenty-four hours in a solution of potassium sulphide, made by dissolving one pound of the sulphide in twenty-four gallons of water.

The copper sulphate treatment, used for wheat, will effectually kill the smut in oats, but will in some degree damage the germinating power of the grain.

In using hot water treatment, be certain to have a tested thermometer, and use only one that is correct.



630.679
M9eb.

Bull. no. 13-16

FOURTH ANNUAL REPORT

OF THE

MONTANA AGRICULTURAL EXPERIMENT STATION

......OF......

THE MONTANA COLLEGE OF AGRICULTURE.

◆

......1897......

◆

WHITE SULPHUR SPRINGS, MONT.
THE ROCKY MOUNTAIN HUSBANDMAN PRINT.
.....1897.....

BULLETIN NO. 13.

MONTANA
AGRICULTURAL
EXPERIMENT STATION

DRINKING WATER.

BOZEMAN, MONTANA, FEBRUARY, 1897.

Bozeman Chronicle,
Book and Job Printers,
1897.

MONTANA AGRICULTURAL

EXPERIMENT STATION.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman.
Peter Koch, Secretary and Treasurer	Bozeman.
George Kinkel, Jr., Vice President	Manhattan.
Walter Cooper	Bozeman.
Nelson Story	Bozeman.

EXPERIMENT STATION STAFF.

S. M. Emery	Director and Horticulturist.
F. W. Traphagen, Ph. D., F. C. S	Chemist.
Frank Beach, B. S	Engineering and Agriculture.
E. V. Wilcox, Ph. D	Entomology.

Jas. D. Borrows, Farm Foreman.

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director,

Montana Experiment Station,
Bozeman, Mont.

NOTICE—The Bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Experiment Station.

Bulletin No. 13. ◆ February, 1897.

DRINKING WATER.

F. W. TRAPHAGEN.

No more important question can concern the farmer than that relating to the purity of his drinking water.

So many diseases are directly traceable to the use of impure water that it behooves us to pay close attention to that which we are using.

A series of samples has been obtained from farms nearby, to be used as the basis of a preliminary report on the condition of our potable water supply. The analytical results obtained from these are appended with remarks on their composition.

Water is never found pure in nature, even rain water contains gases and dust taken up in its descent from the clouds, and more or less of soluble matter obtained in its flow over the roof before it is caught in the cistern.

After the water reaches the ground it becomes rapidly charged with whatever is soluble, either organic or inorganic, in the soil it passes over or through. Water is Nature's great solvent, and it is on account of this solvent power that it becomes so readily contaminated.

The principal constituents of drinking water in which we are interested are the following:

SUSPENDED MATTERS.—The water may be more or less cloudy from the presence of particles of organic or mineral matter floating in it, and these should always be separated by settling or filtering. While it may be considered a safe rule to reject all water having a cloudy appearance, still it is not to be supposed that because a water is clear and sparkling it is safe.

Some of the most dangerous waters are the most beautiful to look upon; the causes of disease being only detected in the chemical laboratory or under the bacteriologist's microscope.

TOTAL SOLIDS.—This comprises all the residue left after evaporating the water to dryness, and consists of the various salts which were in the solution together with a large part of the organic matter.

The important and common mineral constituents are the following:

"CARBONATE OF LIME."—Calcium carbonate, occurring in large quantities, as limestone, chalk and marble. This exists in water mainly in the form of a bicarbonate, which is formed in the presence of an excess of carbonic acid gas. Calcium carbonate is very slightly soluble in water alone, but in the presence of carbonic acid gas its solubility is very greatly increased and considerable quantities of it go into solution.

The presence of salts of calcium and of magnesium in solution is the cause of the "hardness" of water, and the more of these salts there is present the "harder" will the water be, for no lather can be formed until all of the calcium and magnesium which is present has united with the soap; the compound formed by this union is the scum which is seen on the surface of a "hard" water after soap has been rubbed in it. As soon as the soap has united with all of the calcium and magnesium which was present in solution, the remainder of the soap is free to form a lather.

As these salts are usually held in solution by carbonic acid gas, and as this gas is, in great part, driven out of the water by heat, much of the lime and magnesia may be separated by simple boiling. This fact is well known to those who have used hard waters and have noticed the deposits formed on the bottoms and sides of the tea kettle. Many waters may have their hardness greatly reduced by simply boiling them, such waters are called temporarily "hard."

"CARBONATE OF MAGNESIA," (Magnesium carbonate.)—Found in great beds of magnesian limestone. Is usually present in much smaller quantity than calcium carbonate and behaves in much the same way. Neither is known to have any injurious effect upon health.

"SULPHATE OF LIME," (Calcium sulphate.)—Occurs in considerable quantity as beds of gypsum. Is soluble in water to the extent of one part of salt in about four hundred parts of water. It is not separated from solution by boiling and when present in water produces "permanent hardness." This hardness can be removed by the addition of sal soda (sodium carbonate) which causes the formation of the insoluble calcium carbonate mentioned above. It has no deleterious effect when used for drinking purposes.

"SULPHATE OF MAGNESIA," (Magnesium sulphate.)—This is the well-known Epsom salt, and is sometimes, though seldom, present in considerable quantities.

"SULPHATE OF SODA," (Sodium sulphate.)—Commonly known as Glauber's salt. This is the principal constituent of "white alkali," but is rarely present in drinking waters in sufficient quantity to produce an injurious effect.

"CARBONATE OF SODA," (Sodium carbonate.)—Commonly called "sal soda." Is present in the alkaline waters, which may be known by their power of changing red litmus paper blue. Litmus papers are very commonly used in the chemical laboratory to distinguish between acid and alkaline substances. Acids cause blue litmus paper to change to red, while alkaline substances change the red paper to blue. In any considerable quantity sodium carbonate would render the water unfit for use on account of its decided alkaline action. It is this salt that is the basis of the "black alkali" of soils.

"CHLORIDE OF SODA," (Sodium chloride, or common salt.)—This salt is almost always present in water, and its presence is not to be regarded with concern, unless the quantity present rises above the normal amount present in the wells of the neighborhood, when it almost without doubt indicates sewage contamination, because of its common use for household purposes. It is used to determine the possibility of contamination from a suspected source. For this purpose, after the quantity of sodium chloride in the well water is determined by testing samples selected daily for several days, a considerable quantity of brine is added to the suspected source of contamination, for instance, a cesspool, if, after a reasonable lapse of time, the quantity of sodium chloride in the well water has greatly increased, there is no longer room for doubt concerning the source of the contamination.

This compound is rarely present in sufficient quantity to give its characteristic taste to the water.

SULPHATE, CARBONATE AND CHLORIDE OF POTASH are very useful and important plant foods, as may be inferred from an inspection of the composition of plant ashes which consist almost entirely of the carbonate of potash. Aside from this, remarks upon the sodium salts apply to the corresponding compounds of potassium.

ORGANIC MATTER.—The presence of organic matter in the water is objectionable particularly if it is due to animal decay. In any event, a large quantity of organic matter, whether of animal or vegetable origin, is to be regarded with apprehension, for this matter may be considered as giving a hint of the probable presence of harmful bacteria. Bacteria, as well as all other kinds of living organisms, have particular kinds of food which are especially adapted to their needs, and without these foods they cannot thrive. Organic matter is the ideal food for the disease germ and all other kinds of bacteria, and the bacteriologist has this fact in mind when he makes his culture media of various kinds of organic matter. In view of these facts in we should be anxious to see our well waters contain a small amount of organic matter.

FREE AMMONIA.—This constituent results from the decomposition of nitrogenous animal and vegetable matter, and exists in the water in the form of a salt of ammonium, from which the ammonia is easily set free. The test for ammonia is very delicate, the presence of one part of ammonia in one hundred million parts of water being readily detected.

This constituent and the following one, are regarded by most chemists as the most important upon which to base an estimate of the potability of waters.

ALBUMINOID AMMONIA.—This represents the nitrogen present in the water in the form of nitrogenous animal and vegetable matter in a more or less advanced state of decay. The nitrogen is liberated from these compounds in the form of ammonia by the action of an alkaline solution of potassium permanganate.

NITROGEN IN NITRATES AND NITRITES.—The presence of nitrates and nitrites indicates a contamination which occurred sufficiently long ago to allow the organic matter, particularly the nitrogen, as indicated by the test, to become oxidized. The nitrates represent a more complete oxidation than the nitrites, and, under similar conditions, a more remote source of contamination.

GENERAL REMARKS.

If we could imagine a lake of water of great dimensions, with its impervious bed slowly filled up with sand and gravel, with occasionally a layer of clay, until the surface of the water disappears under these additions and is completely lost from sight, we would have a good idea of the conditions existing in most of our valleys.

This underground lake is the "ground water" and it only differs from the ordinary lake in being out of sight, and in frequently having its bed slope, and possessing a motion of a few feet a day.

The water, of course, lodges in the permeable strata of sand and gravel, and has its forward and vertical motion hindered by the beds of clay present. When we fully grasp this idea of the existence of the lake of ground water, we readily see how easy it is for a well, which after all is simply a tap in this general supply, to become contaminated. All the impurities of cesspools, privy vaults and the like, unless they are cemented water tight, sooner or later find their way into the ground water.

Wells should be cemented to a considerable depth, preferably to the bottom, and the curb should rise several inches above the surrounding ground, with a cemented slope for several feet on all sides from the curb, so that it will be impossible for anv surface water to reach the well, without filtering through many feet of soil.

"Perhaps the most dangerous class of water is that obtained from the shallow wells so often found in the country villages and towns, and which after heavy rains is almost certain to become contaminated with sewage from cesspools and open drains. Shallow well water has played a prominent part in nearly all the big epidemics of typhoid and cholera in the country."[1]

"It should be distinctly understood by everybody that clearness and lack of bad taste in a water do not at all signify that it is free from dangerous impurity. Many millions of germs, harmful and harmless, may be present in a glass of water without in the slightest degree impairing its transparency to the naked eye. While it has been many times proven that typhoid fever has been acquired by drinking water from wells polluted with water containing this germ, there is little doubt, on the whole, that polluted well water has been much too often assumed to have given rise to this contagion without adequate proof. * * * The whosesale and indiscriminate condemnation of wells, of which one so frequently hears nowadays, as sources of water supply, do not appear to be just. But so frequent are the offenses against sanitary laws in the situation and construction of wells, that there is little doubt that it would be a positive benefit if at least half of the wells in the United States were closed forthwith."[2]

---

[1] Air and Water, by Vivian B. Lewis, p 163.

"The fact is, that wells, as they exist in most villages, and on many farms in this country, are an abomination and a perpetual menace to the health and lives of those who use them."[3]

PURIFICATION OF WATER.

DISTILLATION.—Various methods are used for purifying water. If it were not for the great expense, distillation would be the method in general use, for the product of this process is practically pure, is entirely soft and ideal in every respect except its taste, which is "flat." This, however, can be overcome by agitating the distilled water with air.

CLARK'S METHOD.—This consists in adding a calculated amount of lime to the water, which causes a separation of nearly all of the lime and magnesia from the water, together with more or less of the organic impurities and other constituents.

The process is based upon the fact that when the excess of carbonic acid, which holds the lime and magnesia in solution, meets with an additional amount of lime in solution it unites with it, rendering it insoluble. The remaining lime and magnesia, no longer having the carbonic acid to hold them in solution, separate as carbonates, carrying with them mechanically many of the other impurities.

FILTRATION METHOD.—Filtration through sand and gravel affords very satisfactory results, provided the filter beds are sufficiently extensive, and the filtration is not too rapid.

Filtration takes from a solution only the solid particles which are not in solution, and may even fail to take out the smaller solids including bacteria. If, however, the soil be pure and the normal amount of oxygen be present, as the water slowly seeps through it, the organic matter, living and dead, may be, and usually is, oxidized and destroyed.

---

[2] Drinking Water and Ice Supplies, Prudden, pp 99 and 100.

[3] Bacteria, Prudden, p 129.

So a soil may be the means of purifying and rendering wholesome the water passing through it.

On the other hand if the soil be allowed to become overcharged with organic matter, by too careless placing of cesspools or privy vaults near the well, or the throwing of kitchen and other household wastes on the ground nearby, instead of being the means of purifying the water passing through it, it may charge the water so with organic matter and bacteria as to make a water, formerly pure, unsafe to use. This is the method upon which we must depend for the purification of our farm well water, and it is highly important that the soil about the well, through which the surface water must percolate, be kept as pure as possible, and that as thick a bed of soil be traversed as can be, by walling, water tight, the sides of the well, if possible, nearly or quite to the bottom.

The water supply of London comes largely from the Thames river and is of course very impure before treatment, which consists in passing the water through filter beds of sand. This gives a product which favorably compares with the supplies furnished our American cities.

An interesting fact is that that these filters do not work so well at first as they do after some little time, about a week. This is explained by the fact that the bacteria can at first pass through the pores of the filter, but after a while these pores become filled with a gelatinous mass of principally harmless bacteria, which imprison and destroy organic matter and harmful bacteria. In view of this, it must not be thought that a filter bed is useful through all time, for, like the soil, it soon becomes overcharged with bacteria and organic matter, and must then be renewed.

ALUM PRECIPITATION AND FILTRATION.—The addition of very small quantities of alum to impure waters is attended with very remarkable results. A coagulum is formed, and much of the soluble matter, and nearly all of the solid matter and bacteria, are imprisoned in it and may separated from the water by simple filtration.

This method is used in many of the large cities of America, the filtration being done by aid of pressure.

If it is believed that the water in use is impure and no other drinking water be available, the easiest treatment to render it usable is to boil it. *Let it be thoroughly understood, however, that mere raising to the boiling point is not sufficient to make an impure water safe for use. It should be boiled for at least half an hour.*

SOURCES OF, AND REMARKS ON, SAMPLES ANALYZED.

No. 189. From well of Bozeman Milling Co., one mile north of Bozeman. A very fair water, as indicated by analysis.

No. 190. From Frank Van Allen's well, one-half mile north-west from Bozeman. Shows a large amount of albuminoid ammonia and of total solids; the former in the absence of much free ammonia, is considered to indicate vegetable contamination. The "hardest" of all samples examined. The addition of a small amount of alum, with subsequent filtration, would have very beneficial results.

No. 191. From A. L. Corbly's ranch, near Spring Hill, 15 miles north from Bozeman. This water is obtained from Corbly creek. It runs about two hundred yards through an open ditch, and from the end of the ditch is piped to the house. An excellent water; by far the least "hard" of all the samples examined. This softness is accounted for by the fact that the creek runs on a bed of gneiss rock instead of limestone, as is the case with nearly all the streams on this side of the valley. The soil is also heavily charged with carbonate of lime in the greater portion of the valley.

No. 192. From Theo. Norman's ranch, Spring Hill. Shallow well; remarkably pure, when depth is considered. The water should be especially protected against surface contamination.

No. 193. From ranch of Orvis W. Smith, Spring Hill. The well, which is 87 feet deep, is situated on a knoll, which accounts for its considerable depth. Of all the well water examined, this is the purest.

No. 194. From Arthur Truman's ranch, Spring Hill. Taken from Spring Hill creek, it is carried through an open ditch for about a half a mile, then in a pipe about one hundred yards. An impure water, not now used for drinking purposes. The nearness of the corrals to the creek, and the pastures bordering on it, account for its impurity.

No. 195. From Harry Smith's ranch, west of Bozeman. The amount of ammonia, both of free and albuminoid, is somewhat high, and would suggest that the well be protected against contamination.

No. 196. From W. E. Harmon's ranch, west of Bozeman. Contains an unusual amount of free ammonia, the presence of which it is difficult to account for, as there are no outhouses near.

No. 197. From W. H. Tracy's ranch, near Nelson Story & Co's mill, one and one-half miles from Bozeman. A fairly pure water.

No. 198. From Clinton Monroe's ranch, Spring Hill. This water is taken from a soft, boggy place on the ranch, and carried in an open ditch to the house.

No. 199. From John Walton's ranch, Spring Hill. This is a very shallow well, and while the sample taken for analysis is pure, still there is always a menace to purity on account of small depth, through which percolating waters must pass in order to reach the well. The well should be carefully walled and curbed. On account of nearness to the creek the ground water probably has a fairly rapid flow.

No. 200. From Bozeman city dumping grounds. The grounds are located near a creek, and the well is within a few feet of it. The water evidently seeps from the creek bottom through the intervening soil to the well. It is a very fair water and is apparently unaffected by the various materials upon the surface.

No. 201. Bozeman city water supply, from hydrant on the corner of Lamme and 7th streets, a "dead end." Whenever these "ends" are not frequently flushed, the amount of organic matter increases very considerably and may even become dangerous in quantity. A comparison of this analysis and that of the following sample, with No. 211, shows what a great difference there may be in the character of the water from the same source, if some of it be allowed to stagnate.

No. 202. From hydrant on the corner of Curtis and 3rd streets. Another "dead end." Remarks upon No. 201 apply also to this sample.

Nos. 203 to 208 inclusive. Samples from wells in various parts of the city of Bozeman. Hardly any of these samples are above suspicion, as would be expected. The safest plan in all cases would be to avoid the use of water from wells in thickly settled districts.

Nos. 209 and 210 are samples from the Story spring, adjoining the College grounds. This water is used in the Experiment Station Farm house. The samples were taken at different times and represent a water of good quality.

No. 211. City water from the Chemical laboratory faucets, situated near the center of the pipe system where a considerable quantity of water is constantly passing. This sample is very pure and shows how much better water is when it has no opportunity to stagnate. Compare with Nos 201 and 202.

TABLE OF ANALYTICAL RESULTS,

REPORTED IN MGS. PER LITRE=PARTS IN 1,000,000.

NO.	AMMONIA.		CHLORINE.	TOTAL SOLIDS.	NITROGEN AS NITRITES.	NITROGEN AS NITRATES
	FREE.	ALB.				
189	.01	.05	16.97	393.00	.00	0.60
190	.03	.14	22.96	601.00	.00	0.60
191	.02	.07	Trace.	91.00	.00	.00
192	.02	.11	0.76	204.00	.05	6.00
193	.00	.03	13.90	306.00	.00	4.00
194	.16	.12	5.00	247.00	.06	0.40
195	.05	.13	2.93	333.00	.00	0.60
196	.16	.08	5.10	317.00	.04	1.00
197	.02	.09	11.48	362.00	Trace.	1.00
198	.02	.07	0.51	222.00	.00	0.40
199	.02	.04	1.02	271.00	.10	0.20
200	.03	.08	8.42	337.00	.00	Trace.
201	.10	.06	2.00	213.00	.00	0.20
202	.08	.12	5.97	214.00	.00	0.40
203	.02	.14	5.13	303.00	.00	.00
204	.04	.12	13.87	464.00	.00	6.00
205	.06	.18	60.87	504.00	.00	10.00
206	.06	.12	12.87	446.00	.00	6.00
207	.04	.06	3.75	292.00	.00	1.00
208	.03	.06	2.00	182.00	.06	0.20
209	.02	.06	17.48	310.00	.00	.00
210	.02	.06	21.86	368.00	Trace.	.20
211	.02	.02	.00	406.00	.00	.00

DIRECTIONS FOR TAKING SAMPLES.

Use, for shipping sample, a two gallon demijohn, preferably one which has not previously been used. Rinse the bottle several times with the water of the well from which sample is to be taken, then, without stirring up the sediment, fill it with the water and cork with a clean cork. Seal, and pack carefully to prevent breaking.

Send a letter of advice, describing location of well, with respect to house, barn, outhouses and corral.

Describe soil in which well is sunk, also the well itself; particularly, state whether it is curbed and tightly walled. Give any further information that may be useful.

Address the sample to

CHEMICAL LABORATORY,
MONTANA EXPERIMENT STATION,
BOZEMAN, MONTANA.

Bulletin No. 14.

Montana Agricultural Experiment Station

A PROFITABLE LITTER.—Eleven pigs, age 6 mos. 27 days, weight, 2350.7 lbs. SOLD FOR $82.27.

Bozeman, Montana, April, 1897.

ROCKY MOUNTAIN HUSBANDMAN,
White Sulphur Springs,
MONTANA.

MONTANA AGRICULTURAL
EXPERIMENT STATION.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman.
Peter Koch, Secretary and Treasurer	Bozeman.
George Kinkel, Jr., Vice President.	Manhattan.
Walter Cooper	Bozeman.
Nelson Story	Bozeman.

EXPERIMENT STATION STAFF.

S. M. Emery	Director and Horticulturist.
F. W. Traphagen, Ph. D., F. C. S	Chemist.
Frank Beach, M. S	Agriculturist and Irrigation Engineer.
E. V. Wilcox, Ph. D	Biologist and Veterinarian.

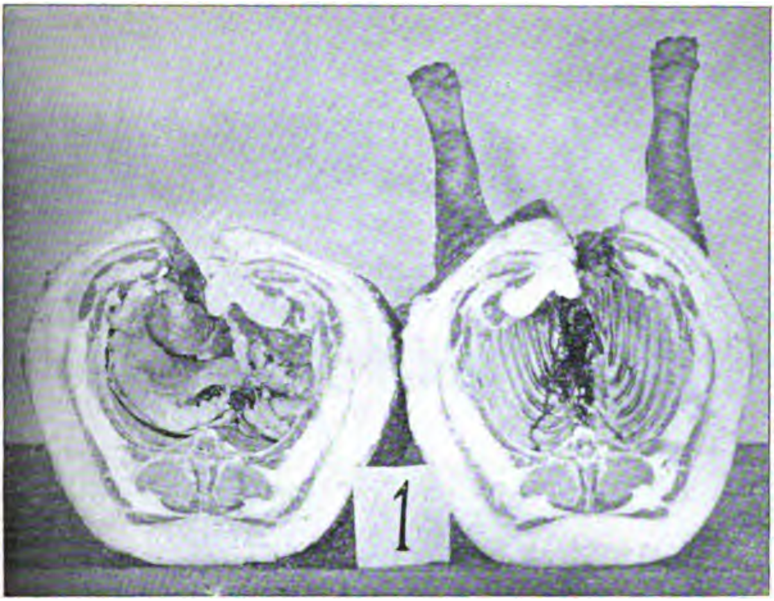
Jas. D. Borrows	Farm Foreman.

Post Office, Express and Freight Station, Bozeman.

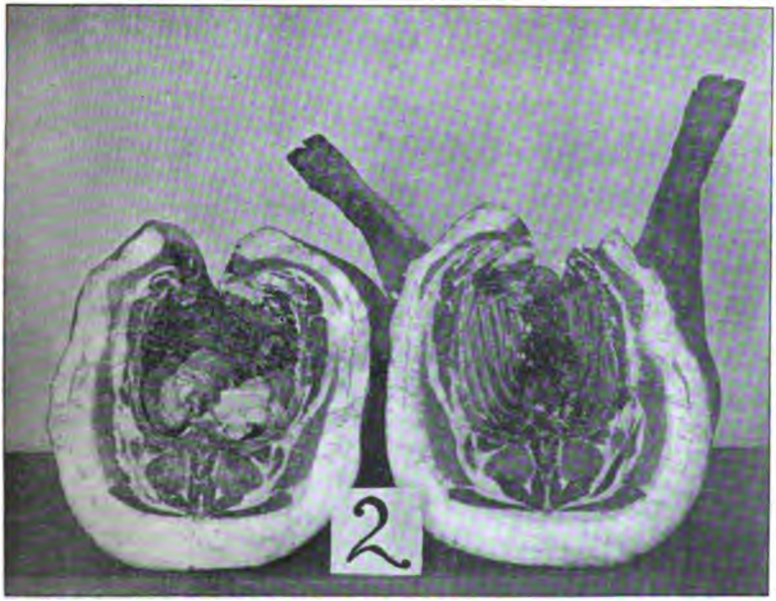
All communications for the Experiment Station should be addressed to the Director.

Montana Experiment Station,
Bozeman, Mont.

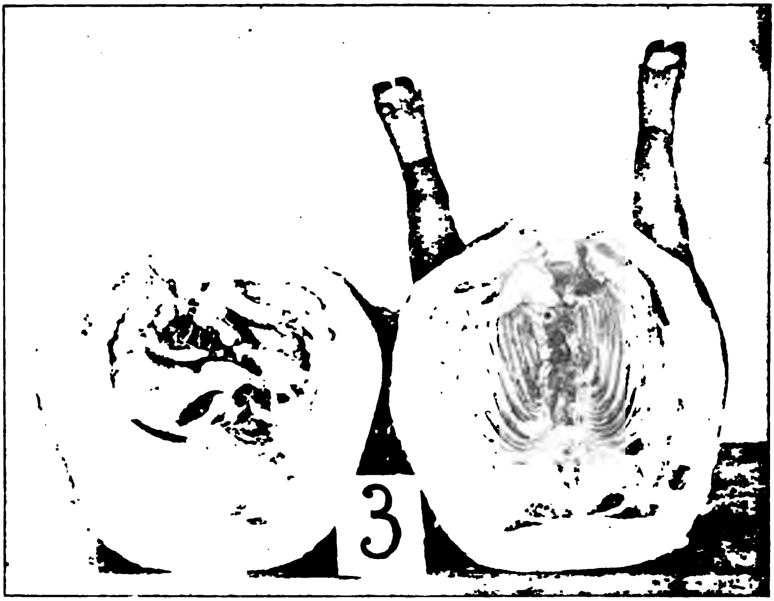
NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.



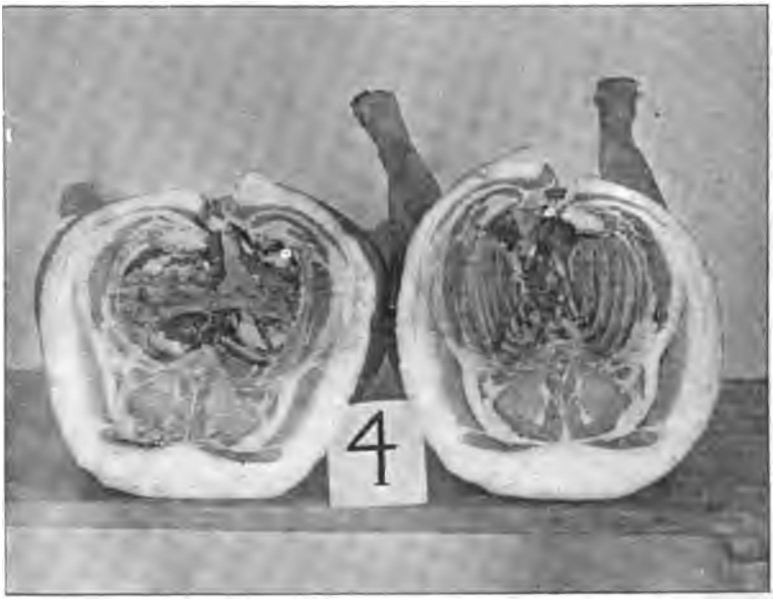
FED BARLEY.



FED EQUAL PARTS OF BARLEY AND WHEAT.



FED EQUAL PARTS OF BARLEY AND PEAS.



FED EQUAL PARTS OF BARLEY, PEAS AND WHEAT.

MONTANA EXPERIMENT STATION.

Bulletin No. 14. *June, 1897.*

MONTANA SWINE FEEDING.

FRANK BEACH.

Montana is blessed with a climate in which the pig thrives. The extreme heat of the summer months is much less than in the corn growing states, and hogs do not suffer from this cause. If given an opportunity they will demonstrate the fact that swine raising is profitable.

Corn can be grown successfully in this state only in a few localities, because of the high altitudes, cool nights, and low humidity ; but these conditions are requisites for the successful growing of wheat, oats, and barley, and Montana excels in the production of these grains. The utilization of these crops upon the farm, and their marketing in the form of pork, mutton and beef, will save money to the farmer and give the consumer a better product than is obtained in the corn growing districts.

Montana does not produce enough pork, ham, bacon and lard for her own consumption, but imports these products from North Dakota, Utah, Minnesota, Nebraska, Kansas, Missouri, Illinois, Iowa and Washington. According to statistics taken from the Fourth Annual Report of the Bureau of Agriculture, Labor and Industry of Montana for 1896, Montana produced 47,208 hogs. Of these 11,355 were killed for home use on the farm, and 35,853 were marketed. The proportion of pork products averaged from reports of principal dealers in the large towns and cities of each county in the state for 1896, show that for 62 towns and cities, eighty-four and thirty-three hundredths (84.33) per cent. of the pork, ham and bacon sold was imported into the state, and for 63 towns and cities reported, eighty-six and sixty-two hundredths

(86.62) per cent of the lard, sold was imported. Then taking eighty-four and thirty-three hundredths (84.33) per cent. as the proportionate number of hogs that are imported we find that Montana in producing 47,208 hogs grows only fifteen and sixty-seven hundredths (15.67) per cent. of her pork. To supply her own markets 312,636 hogs should annually be produced.

Swine feeding is an industry still in its infancy, yet it has been demonstrated by a large number of farmers that the hog thrives upon the Montana farm: He is an animal that will utilize and convert into a profitable commodity a large proportion of the otherwise useless products of the Montana farm. Many Montana farmers have been growing grain and hay, shipping the grain to eastern markets and hauling the hay to town to be sent to the mining camps of the state. They have been buying pork for home consumption at eastern prices plus the railway freight, and marketing grain sent out of the state at eastern prices, less the freight from Montana to the eastern market. Thus bearing the expense of the double transportation. There is no reason why they should not produce more of the leguminous crops: clover, alfalfa, alsike and peas; feed these at home, and after growing their own pork, market the surplus product within the state.

The cost of growing pork in Montana is not great. We have clover, alfalfa and pea pastures, than which there is none better. The barley, peas and wheat of this state have no equal, and they excel the corn of the east as pork producers. These foods when properly combined and fed will give results that challenge any state in the Union. A pig may be grown to a weight of 150 pounds at an expense not exceeding $3.00, counting the pig worth $1.50 at the age of two and one-half months or weaning time. If, at this age he is placed on good alfalfa or clover pasture (the estimated cost of which will be ten cents per head per month) and given one pound of cracked barley a day at a cost of 65 cents a hundred, or 20 cents per month, the total cost will be 30 cents a month. This for four months, gives a cost for maintenance of $1.20, or a total cost of $2.70. He is then ready for the stubble fields where he wi gather up the shattered wheat, barley and peas and convert them in pork. The stubble fields will furnish an abundant supply of food fro the middle of September to the first of November, when he will be rea for the fattening pen. Counting the stubble field worth 30 cents each head, we have a total cost for one hog of $3.00. He will weigh least 150 pounds, at a cost of two cents a pound up to this point. This is on the supposition that pigs arrive the middle of March to the first of April.

To determine the value of pasture for hogs, a drove of the Station swine consisting of 9 brood sows and 44 pigs was turned on alfalfa pasture containing four and one-half acres, August 22nd. The sows had an average weight of 272⅓ pounds. On October 5th they weighed 277⅓ pounds each, showing a gain of 5 pounds during the six weeks. They received no food other than that afforded by the alfalfa pasture. The sows were weighed each week. The gains were greater in August and the first part of September, while the last two weeks there was an actual loss in weight, owing largely to the fact that the pasture became poor, late in the season.

The oldest pigs were farrowed March 18th and the others at later periods until the middle of June. On August 22nd they had an average weight of fifty-seven and one-tenth (57.1) pounds. A creep was made so that they could crawl under a plank into a pen where they were each fed a daily ration of one pound of cracked barley, given in two meals, morning and evening. On the 5th of September the pigs averaged sixty-five and two-tenths (65.2) pounds, showing a gain of eight and one-tenth (8.1) pounds each or four and five hundredths (4.05) pounds per week. At this time three young boars were separated from the drove. The remaining forty-one pigs had an average weight of sixty-four and nine-tenths (64.9) pounds. On October 10th, five weeks later, they had an average weight of seventy-nine and six-tenths (79.6) pounds, or a gain of fourteen and seven-tenth (14.7) pounds each, or forty-two hundredths (.42) of a pound per day. They were turned into the barley, wheat and pea stubbles on October 14th. On the 17th of October they had filled themselves so that they had an average weight of 94lbs, a fill and gain of fourteen and four-tenths (14.4) pounds. On November 14th they had an average weight of one hundred sixteen and eight-tenths (116.8) pounds. During this time they received no grain other han that found in the fields, except on stormy days, which amounted o twenty-four and one tenth (24.1) pounds per head during the five eeks. Thus they gained twenty-two and eight-tenths (22.8) pounds most entirely from the grain obtained in the stubble. Or counting our and one-half (4.5) pounds of grain to produce one pound of pork, ey made a gain in weight due to this grain of five and three-tenth

(5.3) pounds. There was a total gain of twenty-two and eight-tenths (22.8) pounds. Subtracting the five and three-tenth (5.3) pounds gain due to the grain fed during the storms we have a gain of seventeen and five-tenth (17.5) pounds as the amount of gain due to the grain picked up in the stubble. On the basis of four and five-tenths (4.5) pounds of grain to produce one pound of pork, we have seventy-eight and seventy-five hundredths (78.75) pounds of grain as the amount of food consumed by each pig. There were 41 pigs in the field besides the brood sows. These 41 pigs gathered up in grain three thousand two hundred twenty-eight and seventy-five hundredths (3228.75) pounds. An amount which would have been otherwise entirely lost. The fields were harvested in the usual manner. There was very little "down" grain, and the grain that was left did not exceed the usual amount shelled out on the fields of the average farm. On this stubble field seven brood sows ran during the past winter. They received no other food except a portion of the slops from the house and a small grain ration on stormy days when they could not rustle in the field. These sows frequently rooted down through six inches of snow and found sufficient grain to keep them in good condition throughout the entire winter. The stubble fields on the Station consisted of ten and seventy-three hundredths (10.73) acres of peas, ten and forty-four hundredths (10.44) acres of wheat, eighteen (18) acres of barley, and twenty-four (24) acres of oats. The amount of grain figured for the consumption of the forty-one (41) pigs represents only a portion of the grain which is shattered and can be utilized by the hog. This shattered grain could not be saved in any other manner and represents so much clear profit.

On the 21st of November thirty-eight (38) pigs of this drove were selected for a feeding experiment. A litter of eleven which was farrowed July 11th was added to these, making a total of forty-nine (49) pigs. These were selected as being an average lot of pigs, varying in ages from four and one-half to eight months, suitable for fattening on the farm. Another object was to select neither the best nor the poorest pigs, but to secure an average quality. It was believed that the large number entering into the experiment would eliminate variation due to the individuality of the animals. The larger number would give more accurate results, showing that if there was any virtue in th feed given to one pen over that given to the others, the results would b certain to indicate that character.

A great drawback to the value of many feeding experiments is the using of but two or three animals in such experiments. One of these getting off feed, or not possessing desirable fattening qualities will have such an influence upon the experiment that it is a question whether it is the food or the animal that makes the difference in results. These forty-nine (49) pigs weighed five thousand five hundred eighty-five (5885) pounds on November 21st, and were fed a preliminary ration of cracked barley until November 24th, in which time they each consumed an average of twenty-seven (27) pounds of grain andweighed five thousand nine hundred eighty-five (5985) pounds, a gain and fill of four hundred (400) pounds, or eight and sixteen one hundredths (8.16) pounds each in three days. The feeding lots were of an average size of one hundred seventy-five by thirty-two feet, and afforded ample space for exercise. Lot number one contained thirteen pigs weighing 1628 pounds, or one hundred twenty-five and two-tenths (125.2) pounds each. Lot number two contained twelve pigs and weighed 1437 pounds, or one hundred nineteen and eight-tenths (119.8) pounds each. Lot number three contained twelve pigs and weighed 1506 pounds, or one hundred twenty-five and five-tenths (125.5) pounds each. Lot number four contained twelve pigs and weighed 1414 pounds, or one hundred seventeen and eight-tenths (117.8) pounds each. While these pigs varied in average weight, their general appearance and make-up were the same.

PLAN OF EXPERIMENT.

It was desired to determine whether Montana barley, wheat and peas possessed superior fattening qualities, also whether pork produced from these different feeds would not give a large proportion of lean to fat, with firm flesh, thus giving the desired article for bacon and ham. The prices of wheat at Bozeman during the fall and early winter of 1896 was $1.00 per hundred weight. A price at which the farmer could not afford to feed wheat to hogs with pork at three and one-half (3½) cents a pound. However it was desired to determine the pork producing quality of wheat and the results thus be available to the farmer regardless of the selling price of wheat or pork. Barley of good quality was 65 cents per hundred pounds. At this price the farmer could afford to feed it to hogs even if he did not receive a high price for it in the form of pork. The marketing of grain converted into pork means one trip to the market instead of five, and again in feeding out the grain on the farm a large per cent. of the fertility of the soil taken up in the grain is returned to the farm in the form of manure, a fact well worthy of consideration. At present there is no regular market price for peas. Enough of them have not been produced in Montana to warrant their being shipped. The prices have ranged in the past three years from two to four cents per pound, and these have been sold mainly for seed. On the basis of production, however, if we compare them with barley as a standard we have an average yield of 2088 pounds of barley per acre on the Station for the past three years, and of peas an average yield of 1920 pounds per acre. Peas would then have a value of seventy and seven-tenths (70.7) cents per hundred as compared with barley at 65 cents per hundred. The prices of grain in Montana during the past season have been encouraging, but exclusive grain raising is not conducive to the best results in farming. If we can utilize the grain upon the farm and secure a fair price for it by feeding it to hogs, even when the market for grain is low, the farm can be made to yield maximum returns. While at the present prices of grain and pork there is not a large profit in the feeding of hogs, yet there is a sufficient gain to pay for all time and trouble expended, and the cheap summer growth made by using the clover pastures will yield the profit. The barley of Montana has a world-wide reputation for its plump berry and its superior malting properties. The average weight of a struck bushel of barley grown at this Station was $55\frac{2}{3}$ pounds. The average barley production per acre for the years 1894, 1895 and 1896 in the Gallatin Valley was forty-six and three-tenths (46.3) bushels machine measure. More than one hundred samples of wheat as analyzed by the Experiment Station Chemist, Dr. F. W. Traphagen, gave as the highest, seventeen and sixty-two hundredths (17.62) per cent. of gluten, while the highest, of three hundred and ten (310) analyses taken from Jenkins' and Winton's tables gives seventeen and two-tenths (17.2) per cent. The lowest found in any sample of Montana wheat gave nine and thirty-eight one hundredths (9.38) per cent. crude protein, while the lowest of the wheats as taken from Jenkins' and Winton's tables was eight and one-tenth (8.1) pe cent. of crude protein. These figures conclusively prove the richnes of Montana wheat as compared with wheat produced in other state The average yield of wheat per acre in the Gallatin Valley for the yea 1894, 1895 and 1896 was thirty-five and seven-tenths (35.7) bushels p acre.

The Canada field peas produced in Montana are not excelled. The yield of this grain as grown on the Montana Experiment Station during the past three years has averaged thirty-two (32) bushels per acre. The pigs did not bolt the peas as they did the smaller grain, but would take time to masticate before swallowing. The barley and wheat were ground, and all grain was fed dry. It was found that when the pigs were fed whole grain, a portion passed undigested. In order to avoid this the wheat and barley were ground. The grinding was done at an expense of 5 cents per hundredweight. The same results might possibly have been obtained by soaking the grain for twenty-four (24) hours before feeding. A stream of pure water ran through each pen so that the pigs could help themselves thereto at any time of the day or night. They were given salt at regular intervals, and wood ashes were kept constantly in their pens. The pigs were fed at seven o'clock in the morning and six o'clock in the evening. All grain was accurately weighed and a record kept of all food consumed. Lot number one was fed barley. Lot number two was fed barley and wheat equal parts. Lot number three was fed barley and peas equal parts. Lot number four was fed barley, wheat and peas equal parts. The lot fed barley received a food of the nutritive ratio of one to six (1:6). Lot two also had a food of a nutritive ratio of one to six (1:6). Lot three had a food of a nutritive ratio of one to four and four-tenths (1:4.4). Lot four had a food of a nutritive ratio of one to four and nine-tenths (1:4.9). All lots were fed what is known as a narrow nutritive ratio, possessing a large proportion of muscle forming material. The pigs were of such an age and condition that a muscle and growth forming food would best meet their requirements, especially during the first portion of the experiment. The pigs were fed all they would consume at each meal. It required about two hours for them to consume their rations. They were all healthy, growing animals; the majority were grade Poland China, out of good grade sows, and a full blood boar. Several were pure blood Poland Chinas, and a few were half blood Chester Whites. These were equally divid- l, as nearly as possible, among the various lots, so that each lot rep- sented a fair average. The lots were weighed once a week and the eights carefully recorded. It was not deemed necessary to keep a parate account of each pig, as average and not individual results were sired. The experiment may be divided into three periods: the first riod consisting of thirty-two days, the second twenty-one days, and e last of twenty-three days. The following table will show the amount of food consumed by each pen and the gain in weight:

Number of lot.	Number of pigs in lot.	Food consumed Nov. 24 to Dec. 5	Weight of pigs Nov. 24.	Weight of pigs Dec. 5.	Gain in weight.	Pounds of food required to make a pound of gain.
1	13	990	1628	1818	190	5.21
2	12	918	1437	1633	196	4.68
3	12	916	1506	1730	224	4.09
4	12	910	1414	1645	231	3.94

Number of lot.	Number of pigs in lot.	Food consumed Dec. 5 to Dec 12.	Weight of pigs Dec. 5.	Weight of pigs Dec 12.	Gain in weight.	Pounds of food required to make a pound of gain.
1	13	773.5	1818	2003	185	4.18
2	12	640.5	1633	1774	141	4.54
3	12	604.5	1730	1863	133	4.55
4	12	640.5	1645	1779	134	4.78

Number of lot.	Number of pigs in lot.	Food consumed Dec. 12 to Dec. 19.	Weight of pigs Dec. 12.	Weight of pigs Dec. 19.	Gain in weight.	Pounds of food required to make a pound of gain.
1	13	773.5	2003	2148	145	5.33
2	12	684.0	1774	1913	139	4.92
3	12	651.0	1863	1988	125	5.21
4	12	684.0	1779	1940	161	4.25

Number of lot.	Number of pigs in lot.	Food consumed Dec. 19 to Dec. 26	Weight of pigs Dec. 19.	Weight of pigs Dec. 26.	Gain in weight.	Pounds of food required to make a pound of gain.
1	13	773.5	2148	2306	158	4.89
2	12	693	1913	2070	157	4.41
3	12	651	1988	2129	141	4.61
4	12	693	1940	2086	146	4.74

Number of lot.	Number of pigs in lot.	Food consumed Dec 26 to Jan. 2	Weight of pigs Dec. 26.	Weight of pigs Jan. 2.	Gain in weight	Pounds of food required to make a pound of gain.
1	13	773.5	2306	2448	142	5.44
2	12	693	2070	2203	133	5.21
3	11	651	2043	2168	125	5.21
4	12	693	2086	2217	131	5.29

TABLE CONTINUED.

Number of lot...	Number of pigs in lot	Food consumed Jan. 2 to Jan. 9..	Weight of pigs Jan. 2........	Weight of pigs Jan. 9........	Gain in weight.	Pounds of food required to make a pound of gain..
1	13	773.5	2448	2612	164	4.71
2	12	693	2203	2344	141	4.91
3	11	651	2168	2311	143	4.55
4	12	693	2217	2371	154	4.50

Number of lot...	Number of pigs in lot	Food consumed Jan. 9 to Jan. 16.	Weight of pigs Jan. 9........	Weight of pigs Jan. 16...... ..	Gain in weight.	Pounds of food required to make a pound of gain..
1	13	773.5	2612	2766	154	5.02
2	12	693	2344	2481	137	5.06
3	11	651	2311	2433	122	5.33
4	12	693	2371	2517	146	4.74

Number of lot...	Number of pigs in lot....	Food consumed Jan. 16 to Jan. 23.	Weight of pigs Jan. 16.......	Weight of pigs Jan. 23.......	Gain in weight.	Pounds of food required to make a pound of gain..
1	13	773.5	2766	2882	116	6.67
2	12	693	2481	2600	119	5.82
3	11	651	2433	2503	70	9.3
4	12	693	2517	2626	109	6.36

Number of lot...	Number of pigs in lot.........	Food consumed Jan. 23 to Jan 30.	Weight of pigs Jan. 23......	Weight of pigs Jan. 30.	Gain in weight.	Pounds of food required to make a pound of gain.
1	13	686.6	2882	3001	119	5.77
2	12	615	2600	2724	124	4.96
3	11	436.5	2503	2576	73	5.98
4	12	510	2626	2670	44	11.6

Number of lot...	Number of pigs in lot	Food consumed Jan. 30 to Feb. 8.	Weight of pigs Jan. 30.......	Weight of pigs Feb. 8	Gain in weight.	Pounds of food required to make a pound of gain.
1	13	968.5	3001	3128	127	7.62
2	12	867	2724	2818	94	9.23
3	11	814.5	2576	2725	149	5.47
4	12	870	2670	2868	198	4.39

TABLE CONTINUED.

Number of lot	Number of pigs in lot	Weight of pigs Nov. 24	Weight of pigs Dec. 26	Gain in weight	Food consumed	Average daily consumption	Pounds of food required to make a pound of gain	Average daily gain	Average weight of pigs Nov. 24	Average weight of pigs Dec. 26, 32 days later
1	13	1628	2306	678	3319.5	7.98	4.89	1.62	125.2	177.4
2	12	1437	2070	633	2935.5	7.66	4.64	1.65	110.8	172.5
3	12	1506	2129	623	2822.5	7.35	4.53	1.62	125.5	177.4*
4	12	1414	2086	672	2927.5	7.62	4.36	1.75	117.8	173.8

Number of lot	Number of pigs in lot	Weight of pigs Dec. 26	Weight of pigs Jan. 16	Gain in weight	Food consumed	Average daily consumption	Pounds of food required to make a pound of gain	Average daily gain	Average weight of pigs Dec. 26	Average weight of pigs Jan. 16
1	13	2306	2766	460	2329.5	8.50	5.05	1.08	177.4	212.8
2	12	2570	2481	411	2079	8.25	5.06	1.63	172.5	206.9
3	*11	2043	2433	390	1953	8.45	5.01	1.60	185.7	221.2
4	12	2086	2517	431	2079	8.25	4.82	1.71	173.8	209.8

Number of lot	Number of pigs in lot	Weight of pigs Jan. 16	Weight of pigs Feb. 8	Gain in weight	Food consumed	Average daily consumption	Pounds of food required to make a pound of gain	Average daily gain	Average weight of pigs Jan. 16	Average weight of pigs Feb. 8
1	13	2766	3128	362	2428	8.12	6.71	1.21	212.8	240.6
2	12	2481	2818	337	2175	7.88	6.45	1.22	206.9	234.8
3	11	2433	2725	292	1902	7.52	6.51	1.15	221.2	247.7
4	12	2517	2868	351	3073	7.51	5.90	1.27	209.8	239.0

*Pig removed from experiment Dec. 26th, weight 86 pounds.

Lot one gained one and sixty-two one hundredths (1.62) pounds in weight per day for thirty-two days at a cost of four and eighty-nine hundredths (4.89) pounds of barley for each pound of gain. With barley at seventy cents per hundred weight it cost three and forty-two hundredths (3.42) cents for each pound of gain, or with pork at three and one-half cents a pound it gave seventy-one and six-tenths (71.6) cents per hundred for the barley. This was for weight between one hundred twenty-five and two-tenths (125.2) pounds and one hundred seventy-seven and four-tenths (177.4) pounds. Lot two, which was fed equal parts of barley and wheat gained one and sixty-five hundredths (1.65) pounds a day at a cost of four and sixty-four hundredths (4.64) pounds of grain for each pound of pork; or a return for the grain of seventy-five and four-tenths cents (75.4) cents per hundred, with pork at three and one-half cents a pound. Lot three on barley and peas gained one and sixty-two hundredths (1.62) pounds a day at a cost of four and fifty-three hundredths (4.53) pounds of grain for each pound of pork. It will be noticed that these animals consumed less food than the other lots but they put that food to better account, making as great a daily gain as lot number one, but on thirty-six hundredths pounds less food. A substantial saving when a number of pigs are being fed. This food gave a return of seventy-seven and three-tenths (77.3) cents per hundredweight for the grain, with pork at three and one-half cents a pound.

Lot four, fed on barley, wheat and peas equal parts, shows the cheapest gain of all, making a pound of pork on four and thirty-six hundredths (4.36) pounds of grain, and making a gain of one and seventy-five hundredths (1.75) pounds of pork a day. They consumed fifty-three hundredths (.53) pounds less grain than lot one for each pound of increase, denoting the adaptability of this food for the young, fattening pig. The value returned for the grain fed is eighty and three-tenths (80.3) cents per hundredweight. At this stage of the experiment the smallest pig in the drove, which happened to be in lot three, was removed from the experiment as he had contracted the complaint popularly known as the "thumps." He weighed 86 pounds. His removal gave lot three a higher average weight, raising it from one hundred seventy-seven and four tenths (177.4) pounds to one hundred eighty-five and seven-tenths (185.7) pounds. The experiment was continued with the remaining pigs in the same manner as before. At the close of the record period of twenty-one days the pigs were in proper condition to slaughter, and were of a weight that is most desired for market. The cost of bringing the pigs to this condition was such as to a little more than pay for all feed consumed in the fattening with pork at three and one-half cents a pound. During this period lot one made a gain of one and sixty-eight hundredths (1.68) pounds a day at a cost of five and five hundredths (5.05) pounds of barley for each pound of increase. It may be noticed that the cost of producing pork at this stage when the pig was between the weights of one hundred seventy-seven and four-tenths (177.4) pounds and two hundred twelve and eight-tenths (212.8) pounds was sixteen hundredths (.16) pounds of barley greater, or in other words, it took sixteen hundredths (.16) pounds more of barley to make a pound of pork. With pork at three and one-half cents, the increase in weight returned sixty-nine and five-tenths (69.5) cents per hundred for the food consumed. A decrease in the pork producing value of the barley of two and one-tenth (2.1) cents. A small amount, but one on which often hinges the question of a profit or loss.

Lot two, fed on barley and wheat, made a gain of one and sixty-three hundredths (1.63) pounds a day at a cost of five and six hundredths (5.06) pounds of grain for each pound of increase in weight. The value of this mixture appears to be about the same as the barley alone between the weights one hundred seventy-two and five-tenths (172.5) pounds and two-hundred six and nine-tenths (206.9) pounds. There is not enough difference in the ratio of grain consumed to pork produced to warrant the assumption that either barley alone or barley and wheat equal parts possess any virtue over the other.

Lot three fed on barley and peas, made a gain of one and sixty-nine hundredths (1.69) pounds a day at a cost of five and one hundredths (5.01) pounds of grain for each pound of increase in weight. This mixture, between the weights of one hundred eighty-five and seven-tenths (185.7) pounds and two hundred twenty-one and two-tenths (221.2) pounds gave a return of practically seventy (70) cents per hundred for all food consumed.

Lot four fed on barley, wheat and peas, made a gain of one and seventy-one hundredths (1.71) pounds a day at a cost of four and eighty-two hundredths (4.82) pounds of grain for each pound of increase. This combination of feeds gave for weights of from one hundred seventy-three and eight-tenths (173.8) pounds to two hundred nine and eight-tenth pounds a return of seventy-two and six-tenths (72.6) cents per hundredweight for food consumed, showing the best returns of any of the feeds used. From this time on the expense of putting a pound of flesh increased faster than before. The weather during this period was not conducive to good results from feeding. Sometimes the pig preferred to stay in his bed the entire day rather than to get up and go to his feed. The feeding was carried on out of doors. On January 23d five and two-tenth (5.2) inches of snow fell, and on the 24th of January the thermometer registered 19° below zero. On the 26th it was 24° below zero and the weather did not moderate until January 30th. During the first part of the experiment the weather was all that could have been desired, the days were pleasant and warm and no radical changes occurred. The intention was, at the beginning of the experiment, to market the pigs when they weighed 200 to 210 pounds, but when that time came it was thought that additional feeding would be valuable to bring out the cost of putting on the flesh of the pig as he increased in age and weight. The results obtained from lots one and two fed barley and barley and wheat were so nearly parallel in the second period that barley was substituted for wheat wherever it entered into the ration. Lot one made a gain of one and twenty-one hundredths (1.21) pounds a day at a cost of six and seventy-one hundredths (6.71) pounds of grain for each pound of food consumed. An increase in grain for this period of one and sixty-six hundredths (1.66) pounds for each pound of pork produced. The pigs gained less in weight per day and it cost more to put that weight on. Figuring pork at three and one-half (3½) cents the increase in weight gave fifty-two and two-tenths (52.2) cents per hundredweight as the price received for the grain fed. A difference in the value of grain for this period of seventeen and three-tenths (17.3' cents per hundredweight. Lot two in this period received barley alone, the same as lot one. The amount of daily gain one and twenty-two hundredths (1.22) pounds, is nearly the same as lot one, but the food consumed was six and forty-five hundredths (6.45) pounds to produce a pound of pork. This pork would then yield fifty-four and three-tenths (54.3) cents per hundred for the grain, a difference in price of the grain in favor of this lot of two and one-tenth (2.1) cents. Lot three received barley and peas equal parts, the same as during the other periods of the experiment. A pound of gain was obtained at an expense of six and fifty-one hundredths (6.51) pounds of grain. The daily gain was only one and fifteen hundredths (1.15) pounds, less than any of the other lots. The price returned for the grain was fifty-three and eight-tenths (53.8) cents per hundredweight, or one-half cent less than that of lot two.

Lot four received two parts barley and one part of peas. A pound of gain was obtained at the expense of five and nine-tenths (5.9) pounds of grain, giving a daily gain of one and twenty-seven hundredths (1.27) pounds a day. An amount greater than any of the other. The price returned for the grain was fifty-nine and three-tenths (59.3) cents per hundred. Five (5) cents greater than lot two which was the highest return given by any of the other lots.

If we take the first two periods of fifty-three (53) days we find that lot one consumed five thousand six hundred forty-nine (5649) pounds of barley and made a gain of eleven hundred and thirty-eight (1138) pounds in weight, or at the rate of four and ninety-six hundredths (4.96) pounds of grain for each pound of increase in weight. A price for the barley of seventy and six-tenths (70.6) cents per hundred. Lot two consumed five thousand fourteen and five-tenths (5014.5) pounds of grain and gained ten hundred and forty-ty-four (1044) pounds in weight, or four and eight-tenths (4.8) pounds of grain to one pound of gain. A price for the grain of seventy-two and nine-tenths (72.9) cents per hundred weight. Lot three consumed four thousand seven hundred seventy-five and five-tenths (4775.5) pounds of grain and gained ten hundred and thirteen (1013) pounds in weight, or four and seventy-one hundredths (4.71) pounds of grain to produce one pound of gain. A price for the grain of seventy-four and three-tenths (74.3) cents per hundred. Lot four consumed five thousand six and five-tenths (5006.5) pounds of grain and gained eleven hundred and three (1103) pounds in weight, or four and fifty-five hundredths (4.55) pounds of grain to produce one pound of gain. A price for the grain of seventy-six and nine-tenths (76.9) cents per hundred.

REMARKS.

No evil effects were experienced in the feeding of any of these grains; however, it was noticed that in lot three, fed on peas and barley, the excrements were sticky, adhering to the hairs of the body around the anus. The same was noticed to a less extent in lot four, fed on barley, wheat and peas. The health of the animals did not seem to be in any way affected by this characteristic. At the close of the experiment the pigs were sold at Bozeman for three and one-half (3½) cents a pound on foot. Four pigs, one from each pen, of the same average quality and weight, were chosen. These were slaughtered and cut in two at the sixth rib and photographs taken of the carcasses.

Plate number one shows the carcass of the barley fed pig. In this the flesh was firm, but there was a large proportion of fat to lean, not so much, however, as is found in the corn fattened pig.

Plate two shows the carcass of the barley and wheat fed pig. In this we find a greater proportion of lean to fat. The flesh firm and the meat desirable for hams and bacon.

Plate three shows the carcass of the barley and pea fed pig. The quality of the meat throughout is about the same as that of the barley and wheat fed pig, a desirable article of pork.

Plate four shows the carcass of the barley, wheat and pea fed pig. In this we have the largest per cent. of lean to fat. The flesh is firm and the meat is of the best quality for bacon, hams and immediate consumption.

SUMMARY.

Of swine products consumed in this state Montana produces only fifteen and sixty-seven hundredths (15.67) per cent.

To supply home demand 312,636 pigs are required annually.

Pigs thrive in Montana, and by a combination of grain and leguminous pastures, can be grown to a weight of 150 pounds at a cost of two cents a pound. Alfalfa, clover, peas, wheat and barley make the best of pig feed. Alfalfa or clover pasture with a little grain in summer affords conditions for the cheapest growth and the greatest profit.

Pigs fed on barley or barley and wheat at present market prices will pay for all food consumed when pork is three and one-half cents a pound.

The pea combined with grain is well adapted to the wants of the growing animal, and will give the greatest gains on the smallest amount of feed.

The lot fed equal parts of barley, wheat and peas made a gain of one pound in weight for four and fifty-five hundredths (4.55) pounds of food, when the pigs were between the weights of one hundred seventeen and eight tenths (117.8) pounds and two hundred nine and eight-tenths (209.8) pounds.

Pigs make the greatest gains and at a less cost of grain before they reach two hundred (200) to two hundred and ten (210) pounds in weight.

The quality of pork produced from wheat, barley and peas in the various combinations used is firm and well adapted for the production of hams and bacon. The fat and lean of the meat being well distributed.

SWINE PASTURE FENCES.

To profitably produce pork the farmer must pasture swine, both old and young. This necessitates a pig-tight pasture fence. Of materials employed for fence construction lumber is perhaps the best. However, it is expensive in its first cost and subsequent maintenance, and its tendency to collect snow drifts makes it objectionable. Wire fences are cheaper and more durable. We have tried swine fences built of thick set barb wire, wire three inches apart, tightly stretched, stapled to posts 16 feet apart, with stakes between posts four feet apart. It would seem that such a fence would turn the pigs, but it did not. The cuts and scratches caused by the wires heal rapidly on swine, and the little fellows would wriggle through indifferent to the barbs. Later we have used a fence made of smooth wire, three different numbers, woven into a close mesh fence by the Kitselman Bros., fence weaving machine, manufactured in Ridgeville, Indiana. This machine weaves fences of different patterns, various sized meshes, and of different heighths up to 52 inches and makes a neat strong substantial fence, one that will turn any domestic animal. THE DIRECTOR.

BULLETIN NO. 15.

Montana
Agricultural
Experiment Station

Larkspur Poisoning of Sheep.

BOZEMAN, MONTANA, JULY, 1897.

ROCKY MOUNTAIN HUSBANDMAN,
White Sulphur Springs,
MONTANA.

Montana Agricultural
EXPERIMENT STATION.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman.
Peter Koch, Secretary and Treasurer	Bozeman.
George Kinkel, Jr., Vice-President	Manhattan
Walter Cooper	Bozeman
Nelson Story	Bozeman

EXPERIMENT STATION STAFF.

S. M. Emery	Director and Horticulturist.
F. W. Traphagen, Ph. D., F. C. S	Chemist.
Frank Beach, M. S	Agriculturist and Irrigation Engineer.
E, V. Wilcox, Ph. D	Biologist and Veterinarian.

Jas. D. Borrows	Farm Foreman.

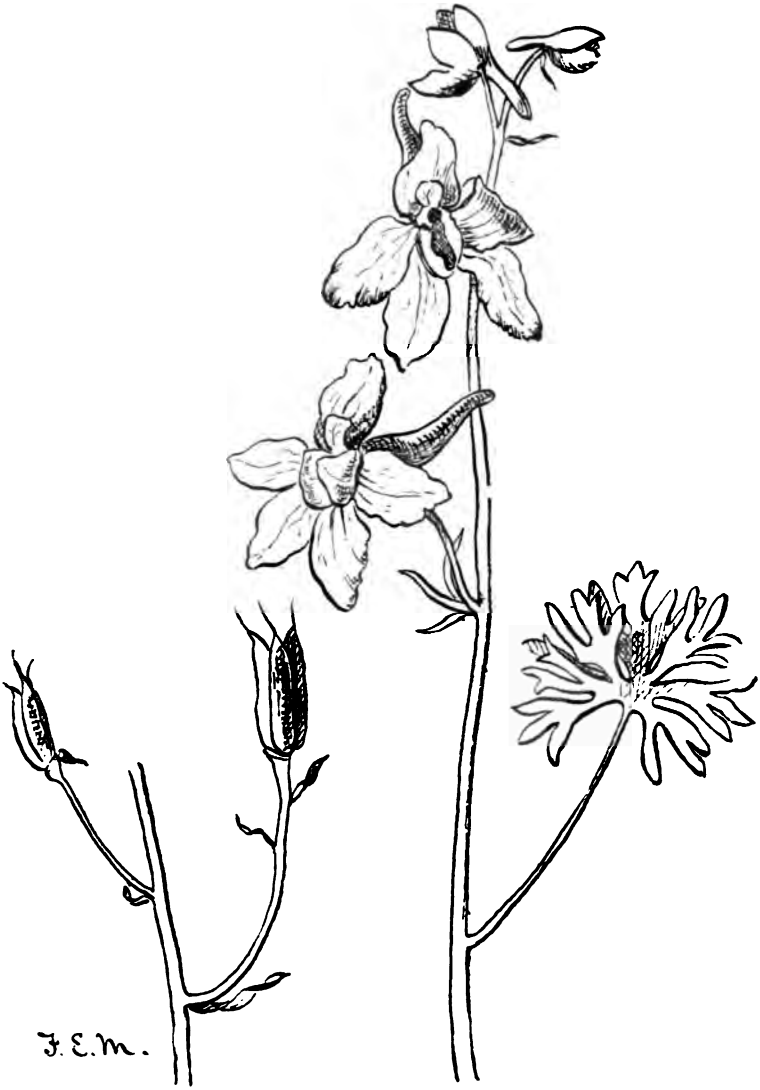
Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the director.

Montana Experiment Station,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

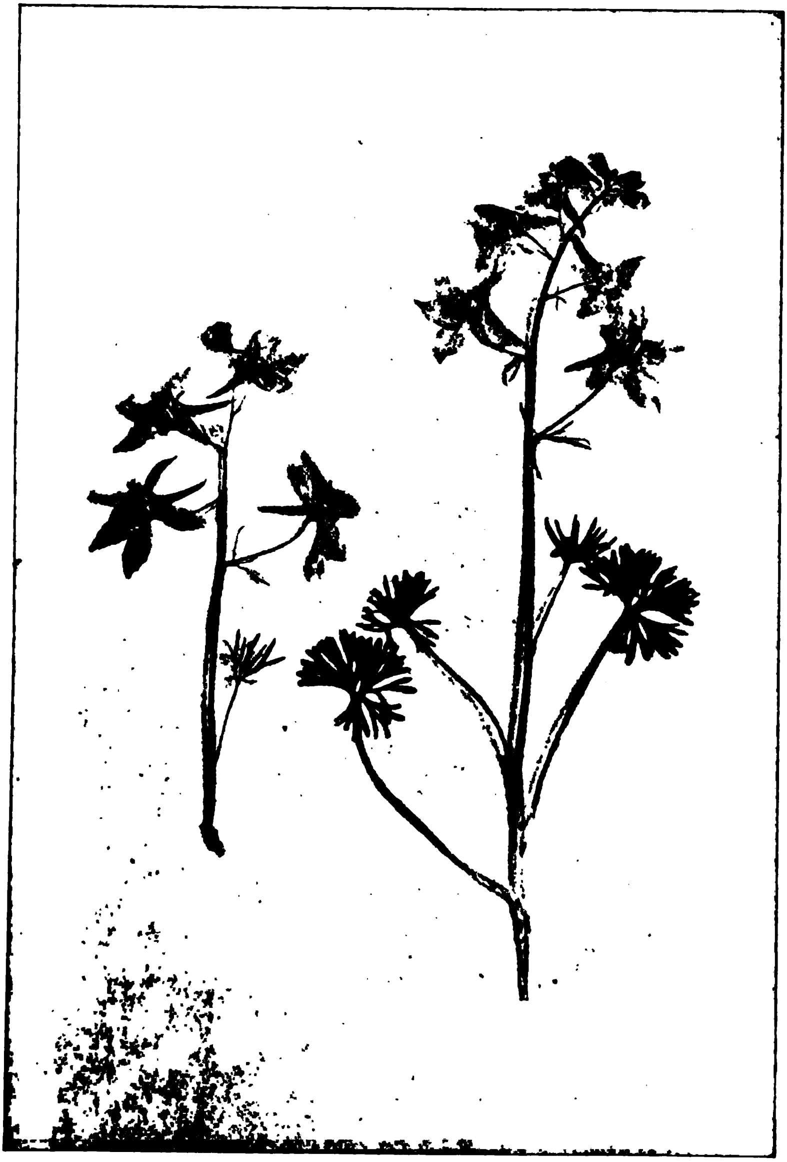
PLATE NO. 1.



PURPLE LARKSPUR, showing Fruit and Flowers.

M7OU

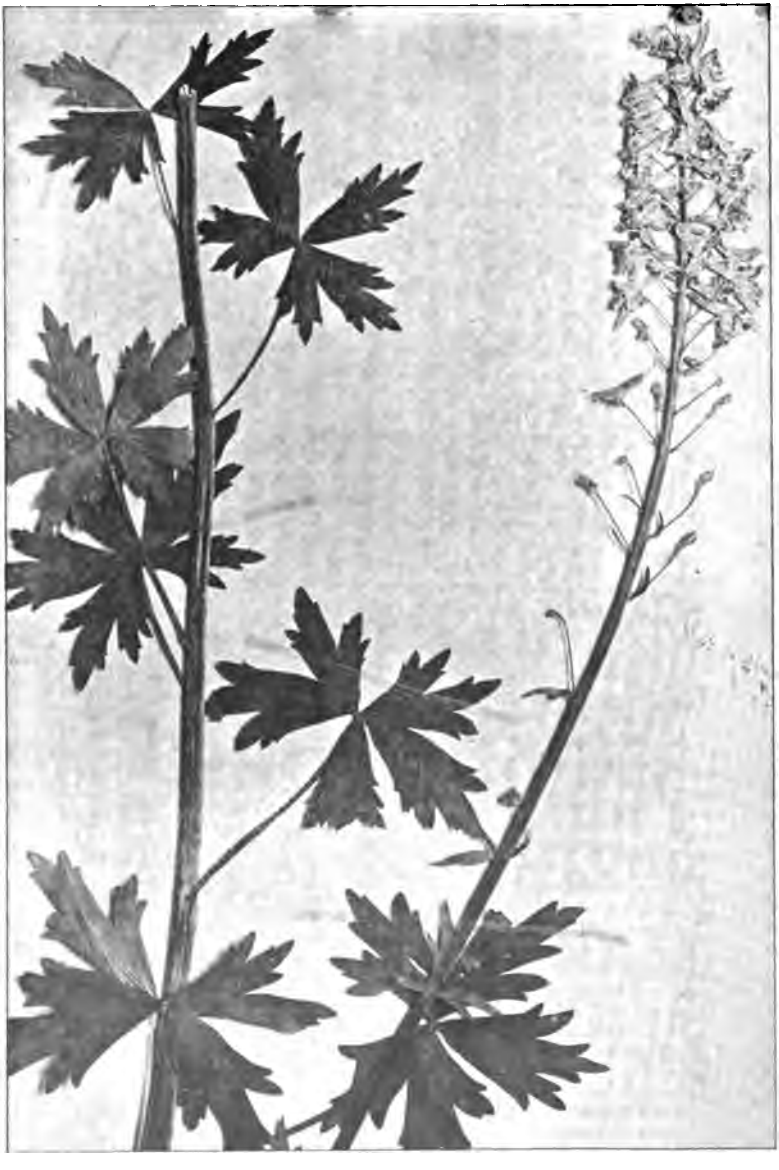
PLATE NO. 2.



DELPHINIUM MENZIESII.

Purple Larkspur.

PLATE NO. 3.



DELPHINIUM GLAUCUM.

Tall Larkspur.

MONTANA EXPERIMENT STATION.

Bulletin No. 15. *July, 1897.*

LARKSPUR POISONING OF SHEEP.

DR. E. V. WILCOX.

For upwards of thirty years stockmen in this country have complained of more or less serious losses from poisonous plants. This has been more especially the case on the large western ranges where stock have subsisted almost entirely upon indigenous plants. The reason for this is probably to be found in the fact that at some seasons of the year the native grasses and sedges are rather scant and stock have taken as food almost any sort of green thing that was to be found. The most serious losses have happened in the spring of the year when stock are tempted to eat various weeds which begin to grow before the grasses.

Judging by the reports made from different parts of the state, the assertion is probably a well founded one that the losses from poisonous plants are greater than from all other causes and diseases taken together. One has only to visit the average sheep ranch to find an "invalid band" of considerable proportions. These invalid bands are almost exclusively made up of sheep which are suffering from the effects of eating some poisonous plant.

The most extensive losses from poisonous plants occur during the months of May and June, but poisoning of one sort and another frequently occurs at other seasons, as late at least as November. Losses occur not only when the stock are feeding under normal conditions on the range, but especially when they are being driven from one place to another. Mr. M. D. Jeffers, of Bozeman, says that formerly he used to drive his sheep some distance for shearing, but that he suffered such loss that he finally had to abandon the plan.

Of the plants suspected as being poisonous by the stockmen we may mention several. The "loco-weed" is perhaps more generally complained of than any other. Ranchmen believe that there are several species of loco-weeds. They are sometimes called white, pink, blue, etc. Species of Oxytropis, Astragalus and even Lupine have been pointed out to us as loco-weeds. Lupine, however, does not have effects similar to those of Astragalus and Oxytropis.

For the past twenty-five years considerable work, chemical and experimental, has been done in this country and in Europe on the subject of loco. Several State Experiment Stations and the Department of Agriculture at Washington have been concerned in the work. Traces of alkaloidal and acid poisons have been detected, but experiments in feeding stock with the suspected plants have been without result. In the Transactions of the State Medical Association of Colorado for 1895, Dr. Karl Ruedi has published the results of his work on loco. He isolated a poisonous acid and by experimentation on healthy rabbits he was able to reproduce the symptoms of the disease.

In regard to the poisonous properties of larkspur little has been done. In 1889 the Oregon Station took up the matter. Two species of larkspur, which were called the blue and the white, were fed to healthy steers. Larkspur plants were chopped and mixed with chopped grass and oats. No effect whatever was produced upon the steers.

Bulletin No. 25, 1893, of the Colorado Station is on the subject "Loco and Larkspur." It is, however, almost entirely devoted to loco and nothing is said about larkspur except a quotation from the Oregon Station Bulletin No. 3, already mentioned.

In Montana nearly all the stock-raisers, with whom conversation or correspondence has been had on the subject, firmly believe that larkspur poisons sheep and cattle. At the Farmers' Institutes held in various parts of the State last winter, we were frequently met with complaints and questions concerning larkspur poisoning, and were urgently requested to come to various places in the spring to investigate the matter. In September, 1896, Dr. Traphagen and the writer, at the request of Dr. Bird, then State Veterinarian, made an investigation into the cause of the death of several horses in Gallatin valley where some sort of poisoning was suspected.

Although the matter has been before the attention of the Experiment Station ever since its organization, no favorable opportunity for a careful study presented itself until May, 1897. At that time and subsequently by direct experiment we were able to get conclusive evidence that one species of larkspur may be the cause of the death of sheep. No ultimate chemical analysis of the species concerned has been made. The Station chemist, Dr. F. W. Traphagen will, however, make such analysis and the results will be reported at another time. At least two species of larkspur have been carefully analyzed and poisonous principles commonly known as alkaloids have been extracted.

We pass now to a detailed account of the case of larkspur poisoning mentioned above.

On May 4th Mr. John Work, of Bozeman, informed me that he had just received a telegram from Dr. Tudor, who was then in Big Timber, stating that the sheep on the Work-Tudor ranch were dying rapidly and that more than one hundred were already dead. I proceeded to Big Timber on the following day and there met Dr. Tudor, and together we drove to the ranch, which is located about 35 miles northeast of Big Timber on Big Coulee Creek.

Dr. Tudor had conceived two possible explanations for the sudden death of the sheep. One was that the sheep might have been maliciously poisoned by some inimical herder, with a metallic poison. The other theory was that the cause might be an epidemic of a specific germ disease.

The actual facts of the case as learned from Dr. Tudor, the foreman, and the herder were as follows: On April 30th a band of about 2,000 yearling lambs were moved from the place where they had been grazing to a new locality about two miles distant. Several of the sheep were taken sick almost immediately upon arriving at the new feeding grounds. Three died within two hours after their arrival, and the number of deaths during the whole day was ten. On the following day thirteen more died and about 500 to 600 showed signs of sickness. The band was then moved away from this locality and during the next day, May 2nd, the greatest mortality occurred, the number of deaths being over fifty. Twenty-five died May 3d, one on May 4th, two on May 5th, and one on May 6th.

All of the sheep that had been sick still exhibited some stiffness and irregularity of movement when we arrived at the ranch on May 5th, but most of them were recovering from the attack. About a dozen however, were in a very bad condition, and one was lying stretched out on its side in the last spasms. I took the sheep by the leg and turned it over, but the shock seemed too severe for it at this stage, for the heart stopped beating immediately and the sheep died.

An autopsy was made at once, which disclosed the following facts: One or two larvæ of the sheep bot were found in the frontal sinus. The brain was in a normal condition. It was not congested and showed no unusual exudation of blood serum in its membranes. The stomach and intestines showed no abnormal appearances. Their walls were neither unusually pale nor unusually ruddy. The contents of the stomach were of the ordinary appearance. No unusual amount of fermentation had taken place, and not the slightest bloating was to be discovered either in the stomach or in the intestines. The liver was neither enlarged nor congested. Its internal structure was unaltered, and the gall bladder was not distended. The bile was of normal color. The pancreas and spleen were also both normal. The kidneys and urinary bladder showed no pathological condition. The caul had the ordinary aspect, but the mesenteries of the small intestine and colon were considerably reddened by accumulation of blood in the veins.

The right side of the heart was full of blood and especially the right auricle was distended almost to bursting. The left side of the heart and the aorta and the arteries in general were comparatively empty.

The lungs were extremely heavy, congested and full of blood. The blood in the blood vessels of the lungs was very dark in color and showed that it had not been thoroughly aerated.

The only natural conclusion from the post mortem was that the animal had died from asphyxia or oxygen starvation, as the result of some sedative poison, a poison which had paralyzed the respiratory centers of the nervous system and had prevented the proper action of the lungs in the purification of the blood.

I had occasion to make several post mortems and the conditions in all were the same. The appearances in the dead animal were so similar to those in the case of death from overdoses of aconite that it seemed we must look for some poison similar to aconite as the cause of poisoning.

In the stomach contents were found the stem, leaves and roots of a species of larkspur, (Delphinium Menziesii). These were present in considerable quantities and in many cases the leaves were so nearly complete that the identification of the plant was rendered quite easy.

This done, the next task was to search for the plant on the range. It was soon found that this species of larkspur occurred plentifully on the range, and that it had a peculiar and definite distribution.

The distribution of the plant may perhaps best be indicated by a general description of the physical geography of the range. The sheep were allowed to graze over about 40,000 acres of land. A part of this tract is reserved for winter range. The whole country is rolling and hilly and exhibits numerous shallow ravines or coulees in which are located small streams of spring origin. The larkspur was not to be found on any of the higher ground, but was strictly confined to the coulees. Along the courses of the small spring streams the larkspur grew in considerable abundance.

On the day when the poisoning occurred, the sheep had followed up one of the spring streams and had fed all day long in the coulee, on the second day they had been driven across a low ridge into another coulee where they again fed till night-fall. During the day and night the mortality was so great that the herder became frightened and on the following day he drove them about two miles away from the locality where they were poisoned.

The sheep had thus for two days fed almost exclusively in places where the larkspur grew in abundance. They therefore had opportunity during this time to get larkspur with their food almost continually.

At that time of the year the larkspur was from three to six inches high and as a rule was not in bloom. Hundreds of specimens, however, were found in flower and some with well advanced seeds. The larkspur plants consisted for the most part simply of radical leaves. The leaves are rather large, bright green and very conspicuous in contrast with the short thin grass of that season of the year. A careful examination left no doubt that they had been eaten. Many of the leaves had been bitten off leaving the stems standing, in other cases they had been pulled up. Fresh sheep tracks were abundant about the patches of larkspur, and it was evident that the leaves had been eaten off or pulled up by the sheep.

The leaves were, as just said, bright green, as were also the petioles or stems of the leaves down to the surface of the ground. Below the surface of the ground the leaf-stems extend for about two or three inches as a white, succulent, root-like structure. There they are attached to a large cluster of thickened fibrous roots. The leaf-stems were easily detached from the root cluster by a gentle pull, both the green and the white portion of the stem coming away with the leaf. The roots proper could rarely be pulled up with the leaves without disturbing the soil. Consequently the sheep had eaten only leaves and leaf-stems as a rule.

Thus the post mortem condition of the sheep, the finding of larkspur in the stomachs of the dead sheep, and the evidence from the field work that larkspur had been eaten by them seemed to indicate conclusively that the larkspur was the cause of the trouble.

Other possible causes of death were fairly excluded by the evidence in hand. We made an examination of all the territory over which the sheep had grazed during the two days mentioned. There was not the slightest evidence, either from the post mortem or from the field of malicious metallic poisoning. The sheep had been salted and had not eaten any alkali during the two days. Alkali poisoning was hence out of the question. The autopsies disclosed no signs whatever of any specific or organic disease. We also made a careful search for any other plants which might be poisonous, but did not find any such plants.

Besides the native grasses and sedges the following plants were to be observed upon the range : One species of phlox, or moss pink; one species of lupine; one species of oxytropis, or loco-weed; two species of astragalus, or milk-vetch; several members of the mustard family; a violet; two species of peucedanum of the parsley family; a buttercup; the common shooting-star; cinquefoil, beard-tongue; wild onion; wild currant; wild rose and a species of saxifrage.

Aside from the fact that none of these plants are known to be poisonous from a chemical analysis, their distribution did not accord with the facts of the poisoning. A species of plant of the lily family, however, became the object of some attention about two weeks subsequent-to the events narrated above. At this time the herder moved the sheep back to the locality where they had previously heen poisoned. A more serious poisoning now occurred than at the former time. The whole band of sheep, now numbering 1,900 became sick and about 150 of them died. In the interval of two weeks between the two cases of poisoning a plant known as Leucocrinum montanum had rapidly developed and its fragrant white flowers were everywhere to be seen on the higher ground of the range. An investigation of the matter, however. showed conclusively that the larkspur was again the cause of the trouble. Mr. John Work, an experienced and extensive stock-raiser, says that from conversation with his brother, who is foreman of the ranch, it was apparent that the sheep had again been poisoned with the larkspur. The larkspur was older and larger than before but the sheep had eaten it again and manifested exactly the same symptoms of poisoning as previously.

REMEDIAL AND PREVENTIVE MEASURES AGAINST LARKSPUR POISONING.

In the first case of poisoning described above, we experimented with various remedies with various results, but with considerable success. A somewhat detailed account of these remedies will therefore be in place here.

In the first place it is perhaps necessary to state that we had nothing to guide us in the way of previous publications or work on the subject. The only thing which may be said to have furnished a hint in our treatment of the case was the fact that the sheep showed symptoms very similar to those of poisoning from over-doses of aconite. As is well known, aconite is a powerful drug, and in large doses acts as a sedative poison, or depressant. Its action is chiefly on the heart and respiratory organs. The strength and frequency of the pulse are reduced. Breathing is slow and deep, and the general sensibility of the skin is partly deadened. The blood vessels of the skin are relaxed, and as a result of this we get a perspiration, lowering of the temperature, and a general weakening of the muscular force.

The symptoms shown by sheep poisoned by larkspur have a general resemblance to those of aconite poisoning, but are somewhat different in several particulars. The first signs of the poisoning are a slight general stiffness and a straddling gait, especially of the hind legs. The stiffness becomes more and more pronounced until walking is quite difficult and evidently painful. Soon there are manifested various involuntary twitchings of the muscles of the legs and sides of the body. There is a loss of control or co-ordination of the muscles. There is ordinarily no increase in the quantity of the saliva, no dribbling of saliva from the mouth, no champing of the jaws or attempts at swallowing. The sheep manifest none of the mental disturbances frequently seen in cases of poisoning from other sources, as for example loco-weed and lupine. There is no impairment of the special senses. The sheep seem to hear and see as well and as correctly as under normal conditions of health.

No indications of any disturbances of the digestive functions are to be seen. The appetite remains good, and the sheep eat up to the very last. They were observed eating industriously during the intervals between the attacks of spasms which they have during the last stages.

At first the frequency of the pulse and of the respiratory movements is lessened and the temperature is lowered. The pulse remains very weak, but in the later stages becomes very rapid, in some cases 130 per minute, Toward the last also the respiration is very shallow and rapid. During the final convulsions the respiration is sometimes 120 per minute but so shallow that the air is simply pumped up and down the windpipe. The air in the lungs is therefore not renewed and the animal dies by asphyxia or suffocation.

As long as the sheep can stand on his feet, or walk, he keeps up with the herd as nearly as possible. The exercise, however, excites him, makes his respiration more rapid, and he has frequently to lie down for a moment and then get up and hobble along after the herd. The worst cases can thus easily be detected, since they straggle behind the rest of the herd.

The later stages of the poisoning follow rather rapidly. The involuntary movements become more frequent and more severe. All four legs tremble and shake violently. In fact all the muscles of the body contract spasmodically until the animal totters over on his side and dies in the most violent spasms.

These symptoms which were very constant in the several hundred sheep affected with the poison, made it evident that the larkspur had the effect of arresting the heart's action and respiration and of paralyzing the spinal cord. Stimulants were therefore necessary.

The herder had tried bleeding the sheep but, of course, with no success. With an already lowered temperature bleeding would still further reduce the temperature and weaken the animal. Bleeding may give relief in some cases of poisoning, but not where larkspur is the plant concerned. Lard also had been given internally, and no noticeable effect was produced by it. Lard is especially useful where there is bloating, and in larkspur poisoning there is no bloating.

Where the sheep had eaten but a small quantity of larkspur. and were noticed soon afterwards, the administration of ammonia or alcohol was found to give good results. One-half cupful of alcohol in water or one tablespoonful of ammonia in a cup of water was given as dose. We tried also in the earlier stages "XXX" liniment internally in doses of a teaspoonful. It seemed not to have much value for this purpose.

In the later stages, neither alcohol, nor ammonia, nor "XXX" liniment, when given internally, appeared to have the slightest effect. In fact during the last violent stages, the giving of any medicine by way of the mouth seemed useless and even dangerous, for the sheep were unable to swallow and choked to death. During the first stages three drachms of ether given by the mouth had a good effect, and in the later stages ½ drachm of ether given hypodermically stimulated the heart's action and respiration. Squibb's ether was used in both methods.

The most effective remedy which was tried, however, was a hypodermic injection of atropine sulphate. A solution was prepared in camphor water in the proportion of four grains of atropine to one fluid ounce of camphor water. Several sheep were treated by this method, and all but one so treated recovered. Doses of three different sizes were administered: ⅓, ¼ and ⅙ of a grain of atropine sulphate. This was in solution in camphor water as just described, so that in order to give the atropine in the quantities mentioned, it was necessary to use 40, 30 and 20 minims respectively of the solution.

Atropine as a direct stimulant of the heart's action and respiration is perhaps the most powerful drug known to medical science. When used hypodermically its effects are much more immediate than when taken into the stomach, and consequently the doses should be smaller. One-third of a grain is a large dose for an animal of the size of a sheep. In fact 1/20 of a grain is quite sufficient in the earlier stages of the poisoning.

But the sheep to which these large doses were given were in the very agonies of death. Nothing could be given them by the mouth for the simple reason that the sheep could not swallow. They were lying on their sides and their whole bodies were in spasms. The respiratory movements were extremely rapid but so weak and shallow that the sheep were getting no pure air into the lungs.

The atropine solution was injected under the skin in the region of the shoulder. The effect of the atropine was shown almost immediately. The pulse at once became stronger, the animal drew a few deep breaths and then began to pant noisily. One minute after the atropine was administered the sheep was lifted upon his feet when he at once ran away panting loudly. The breathing soon became easier, the involuntary muscular movements ceased, and within five minutes time the sheep was lying down in a natural position and was almost as quiet as in health.

All sheep, with one exception, which received this treatment, reacted in the same way and recovered. This one exception was an interesting case. The sheep had already passed through its last violent spasms, breathing had nearly ceased, and the pulse was so weak as to be almost imperceptible. Atropine (⅓ grain) was given as in the other cases. The patient began to breathe deeply and loudly, When placed upon his feet he ran several rods and fell again. The pulse and breathing soon became very irregular and intermittent and at last breathing actually ceased. About one teaspoonful of ammonia was at once dashed into each nostril and the sheep was vigorously shaken. The fumes of the ammonia reached the lungs and caused the sheep to gasp. Breathing was restored. The sheep got up and walked away to a distance of 100 yards. After a few minutes his breathing seemed to be growing weaker and we attempted to give him ammonia in water by the mouth. He could not swallow, however, and as a consequence strangled and died.

In this particular sheep the inability to swallow may have been in part the effect of the atropine. In large doses atropine paralyzes the muscles of the gullet. But sheep which had not been given atropine had a similar difficulty in swallowing.

In our experience we found atropine to be the most prompt and satisfactory remedy, and we would therefore recommend the use of this drug whenever it can be had conveniently. Great precaution should be exercised in its use, since it is a powerful medicine. One should always know exactly how much he is administering. It is only in small doses that atropine has the desired stimulating effect. In large doses it has the opposite effect. We would recommend giving $\frac{1}{6}$ to $\frac{1}{4}$ grain in the later convulsive stages and in the earlier stages or in mild cases $\frac{1}{20}$ to $\frac{1}{15}$ of a grain. These doses are for sheep. For cattle we would use four or five times as much, about one grain of atropine, depending somewhat on the size of the animal and the severity of the poisoning.

In the later convulsive stages ammonia fumes in the nostrils act promptly and powerfully. Breathing is stimulated and deepened.

If given soon after the sheep have eaten the larkspur ammonia and alcohol are useful stimulants. They may be given together in water.

Ether in small doses (2 to 3 drachms in water) has also a beneficial effect.

It is well to remember that alcohol, ammonia, ether and atropine stimulate the heart's action and respiration only when given in moderate doses. In large doses they all have the opposite effect, or act as paralyzers and depressants.

Care in the management of sheep after they are poisoned is quite as important as the giving of medicines. Sheep poisoned with larkspur should be kept as quiet as possible. A trifling fright or excitement may throw them into spasms, and thus result fatally. From the very first, the poisoned sheep have considerable difficulty in keeping up with the rest of the herd. They have a stiff and trembling gait. It becomes necessary for them frequently to stop for a moment to rest. In this way they repeatedly fall behind the herd and then run to overtake it again. Thus their excitement is constantly increased until they fall down in spasms.

As soon as the stiffness and straddling gait, which are the first symptoms of larkspur poisoning, are noticed, one or the other of two methods of procedure should be adopted. Either the whole band of sheep should be herded closely and prevented from moving as fast as it usually moves, or which is perhaps still better the poisoned sheep should be separated from the others and kept as quiet as may be.

From observation of the action of sheep under the influence of larkspur poisoning, nothing could be more apparent than the advisability of keeping the sheep as quiet as possible. About five o'clock in the afternoon, the herder began to urge the sheep along toward the corral. Many of the sheep still showed some stiffness in the hind legs. It was five days after the poisoning had occurred and it looked as if all the sheep, which were to die from the effects of the larkspur, had died. The herder made the band move a trifle faster than usual for about one half-hour. Many of them rapidly became worse during that short time, and some of them had to be taken into a wagon and hauled tc the corral. When we reached the corral they were in their last spasms and could not get upon their feet until treated with atropine as described above.

Not only is too much exercise dangerous, but any fright is apt to prove fatal. The heart's action is so weakened by the larkspur that at any sudden fright the heart stops beating altogether, and the sheep dies without a struggle. These observations should indicate to any stock-raiser the care which is necessary in a case of larkspur poisoning.

There can be no doubt that even in serious poisoning, not all of the sheep which have eaten larkspur die. The mortality is increased by driving the sheep too rapidly or by worrying them by dogs or otherwise. Careful management will bring a large proportion safely to recovery, and will prevent the development of the worst symptoms in sheep which have not eaten any large quantity of the larkspur.

In larkspur poisoning as in other cases, prevention is better than cure, and in order to keep the sheep from being poisoned it is necessary for the herder to know larkspur at sight in all its stages. He should be able to recognize the first leaves which come up in the spring as well as the complete plant in bloom.

In Montana, so far as we are aware, there are but two species of larkspur which are common. Larkspur belongs to the genus of plants known as Delphinium, and botanists distinguish the two species by the names, Delphinium Menziesii D. C., and Delphinium glaucum Nuttall. Larkspur belongs the the Crowfoot family, which includes such well-known plants as clematis, buttercup, anemone, columbine and aconite. Most of the plants of this family have an acrid juice and at least the larkspur and aconite possess poisonous principles or alkaloids.

The following definitions will, we hope, serve to enable anyone to identify the two species of larkspur which we know to be common in the state.

Delphinium Menziesii is the smaller of the two species. It ordinarily attains a height of from six to eighteen inches. The plant is smooth at its base, but is usually hairy above and upon the flowers. The leaves are five-parted in a palmate manner, and the parts are again cleft two or three times. The ultimate divisions of the leaf are rather narrow. The flowers are of a rich purple color or dark blue, about one inch across when fully expanded. Each flower has a backward projecting spur about one inch in length. The outer row of flower parts are five in number and the upper one is prolonged backwards into the just mentioned spur. The inner row of floral parts or petals are four in number, arranged in two pairs. The upper pair is light blue with darker streaks. All four petals are small as compared with the outer row of floral parts.

Perhaps the only plant whose leaves resemble those of the larkspur and which is in condition to be mistaken for larkspur in the early spring is lupine. Its leaves shoot up in clusters much in the same way as do those of larkspur, but the leaf of the lupine is divided into seven to eleven simple unbranched parts.

This species of larkspur is pretty generally distributed over the state. We have seen specimens from the following counties: Flathead, Teton, Missoula, Ravalli, Deer Lodge, Lewis and Clarke, Jefferson, Madison, Gallatin, Meagher, Park, Sweetgrass, Yellowstone and Carbon. It occurs at all elevations. We have found it from the lowest valleys up to a height of 10,500 feet.

The other common species of larkspur in Montana is known to botanists as Delphinium glaucum Nuttall. In some localities cattle-raisers call it "aconite." But the pure aconite, so far as our observation extends, is found only high up in Gallatin county in the vicinity of the Park, and inside of the Park. We received specimens of supposed aconite from Big Timber, but they proved to be Delphinium glaucum. This species of larkspur often reaches a height of six feet. The ordinary specimens are from three to five feet high. The stem is leafy and considerably branched. The leaves are nearly circular in outline, but are palmately divided into 3 to 5 divisions which are wedge-shaped. The primary divisions are two to three times cleft and finally these secondary divisions are themselves deeply toothed. The uppermost leaves are much smaller with narrower divisions. The flowers are built on exactly the same plan as are those of the other species of larkspur. They are much smaller and usually of a lighter color. The color varies from dark blue to almost white, but is usually light blue. The flowers are more crowded in a close, compact raceme, and the flowering pedicels are short. The pods, when ripe, are nearly erect and are hairy, as are also all other parts of the plant.

We have found this plant distributed from the lower altitudes up to a height of 9,000 feet. It has a range similar to that of the smaller species, and is usually very abundant in the localities where it occurs.

Besides the two species already mentioned we should perhaps refer to two other species of larkspur found in Montana. Dr. P. A. Rydberg, of Columbia University, informs me that he has collectep specimens of Delphinium scopulorum Gray at Lima and on Electric Peak. This species differs from D. glaucum in its more finely divided leaves, its smaller size and brighter green colors. It is too rare in the state to be of much economic importance.

Nuttall has described a species under the name of bicolor. In practice, however, it is about impossible to distinguish it from D. Menziesii and I believe that these two supposed species belong together as one species.

It will be unnecessary for me to give a description of aconite since, as far as my knowledge goes, it has not been found in Montana except near the edge of the Park. Several stock-raisers have reported to me cases of deaths from aconite poisoning but on investigation the plant was found to be in every case the tall larkspur or Delphinium glaucum, which is frequently called aconite by ranchers. Aconite and larkspur are two distinct genera of plants and are easily distinguished the one from the other.

Although the conclusions drawn from our field work and post-mortem examinations were considered well founded, we decided to test the matter further by a direct experiment. From pulverized dried plants of larkspur (Delphinium Menziesii) extracts were made in water, alcohol, chloroform and benzole. The alcoholic extract was spoiled by heating too highly while distilling off the alcohol. The extracts in chloroform and benzole on the other hand were quite successful. The ordinary chemical tests applied to these extracts showed the presence of alkaloids No attempt was made to determine just what alkaloids were extracted. As said above that will be done in the near future. At this time we simply wished to get an extract which would as far as possible contain all the active principles of the plant.

Mr. Jas. Vestal, of Big Timber, kindly offered us sheep to experiment upon and on Nov. 6, 1897, we went to the ranch of which Mr. Vestal is manager. Three yearling lambs were selected for experimentation. The first lamb was given the chloroform extract of larkspur. Twenty-five grammes of the dried plants had been pulverized and then steeped at a low temperature in chloroform for one-half hour. The extract was poured off and slowly evaporated to dryness and then dissolved in one ounce of water. This was given to the first lamb by the mouth. After thirty minutes the lamb showed signs of stiffness, and at the end of two hours the lamb died with convulsions and other symptoms just such as we saw in the Work-Tudor sheep. A post mortem examination made immediately after death disclosed also the same conditions as those recorded above.

The second and third lambs were given larkspur extracts hypodermically. The second was given one drachm of the chloroform extract made as just described. The third was given one drachm of a benzole extract of larkspur made in the same way as was the chloroform extract. After fifteen minutes both lambs began to show symptoms of larkspur poisoning and at the end of one hour the symptoms were so plain and pronounced that it was considered useless to sacrifice the lambs to the experiment. Both were therefore given one-eighth of a grain of atropine, which with the aid of a small dash of ammonia in the nostrils counteracted the effects of the poison and the lambs recovered completely.

These experiments are quite in accord with the conclusions reached in the field work, and furnish another strong piece of evidence to the correctness of those conclusions, not only as to the cause of the poisoning but as to remedies to be used.

Plate I is from an India ink drawing by Mrs. F. E. Marshall, of the Agricultural College.

Plates II and III are from photographs by Dr. F. W. Traphagen, Chemist of the Experiment Station.

BULLETIN NO. 16.

Montana
Agricultural
Experiment Station.

......OF......

THE COLLEGE OF AGRICULTURE OF MONTANA.

Fourth Annual Report

...OF...

Treasurer, Director, Horticulturist, Chemist, Biologist and Agriculturist.

BOZEMAN, MONTANA, FEBRUARY 1, 1898.

ROCKY MOUNTAIN HUSBANDMAN,
White Sulphur Springs,
MONTANA.

Montana Agricultural
EXPERIMENT STATION.

LETTER OF TRANSMITTAL.

Bozeman, Montana, February 1, 1898.

To His Excellency, Robert B. Smith; Governor of Montana :

Dear Sir :—I have the honor to transmit to you herewith the Fourth Annual Report of the Montana Agricultural Experiment Station.

Respectfully,

S. M. Emery, Director.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman.
Peter Koch, Secretary and Treasurer	Bozeman.
George Kinkel, Jr., Vice-President	Manhattan
Walter Cooper	Bozeman
Nelson Story	Bozeman

EXPERIMENT STATION STAFF.

S. M. Emery,	Director and Horticulturist.
F. W. Traphagen, Ph. D., F. C. S	Chemist.
Frank Beach, M. S	Agriculturist.
E. V. Wilcox, Ph. D	Biologist.

Jas. D. Borrows	Farm Foreman.

Post Office and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

Montana Experiment Station,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

REPORT OF THE TREASURER OF THE BOARD.

The Montana Experiment Station, in Account With The United States Appropriation, 1896-97.

DR.

To Receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30th, 1896, as per Act of Congress, approved March 2, 1887	$15,000.00
To Sales Farm Produce	1,946.17
To State of Montana	10,057.15
Total	$27,003.32

CR.

By Salaries	$ 6,872.58
Labor	3,040.71
Publications	561,00
Postage, Stationery	189.44
Freight and Express	346.47
Heat, Light and Water	278.83
Chemical Supplies	180.00
Seeds, Plants and Sundries	415.62
Fertilizers	20.00
Feeding Stuffs	44.35
Library	180.27
Tools, Implements and Machinery	584.86
Furniture and Fixtures	889.02
Scientific Apparatus	372.45
Live Stock	454.70
Traveling Expenses	76.80
Contingent Expenses	10.00
Buildings and Repairs	11,502.95
Balance	983.27
Total	$27,003.32
By Balance Farm Produce Acct	983.27

We, the undersigned, duly appointed auditors of the corporation do hereby certify, that we have examined the books and accounts of the Experiment Station of the Agricultural College of Montana, for the fiscal year ending June 30, 1897, that we have found the same were kept and classified as above, and that the receipts for the year from the Treasurer of the United States, are shown to have been $15,000.00; from the Treasurer of Montana $10,057.15, and from sales of farm produce $1946.17, and the disbursements $26020.05. For all of which proper vouchers are on file and have been by us examined and found correct, thus leaving a balance of $983.27, from farm sales account. We farther certify that the expenditures have been solely for the purposes set forth in the act of Congress approved March 2, 1887.

Signed,
PETER KOCH,
WALTER COOPER,
GEORGE KINKEL, Jr.
Auditors.

ATTEST:—PETER KOCH,
Custodian.

MONTANA EXPERIMENT STATION.

Bulletin No. 16. *February, 1898.*

Annual Report of the Director for the Fiscal Year Ending June 30th, 1897.

STATION STAFF.

E. V. Wilcox, Ph. D., was elected and began his official duties as Experiment Station Biologist in September, 1896.

Frank Beach, M. S., was elected and began his duties as Experiment Station Agriculturist and Irrigation Engineer, July 1896.

W. L. Williams, Veterinarian, resigned September 1896.

EXPERIMENT STATION IMPROVEMENTS.

From the Montana State appropriation of $100,000 (one hundred thousand dollars) there was set apart and expended by the Executive board the sum of $10,057.15 (ten thousand fifty-seven and fifteen one hundredth dollars) in the erection of a chemical laboratory, used jointly by the Experiment Station and the College of Agriculture. Many competent authorities who have inspected this structure, pronounce it, and its modern equipment, as being among the very best for its purposes in the United States.

A detailed description, together with ground plans and views, appear elsewhere in this report, under the report for the chemical department of the Station.

FARM IMPROVEMENTS.

Restricted as is the Station to funds arising from the sale of farm products, for farm improvements, the greatest care is necessitated in expending this fund. During this fiscal year a hay barn 25x50 feet, 16 feet high has been put up in the center of the farm, this is utilized in storing clover hay.

The Gallatin Valley is well adapted to growing this legume; and under the present management much will be made of this crop. It is not well to stack this in open field, as from its character it is easily injured by the rains of fall and spring. It was thought wise to locate the barn in the geographical center of the farm, so as to give a short haul from the different fields. It is expected to use this crop on all lands in turn, as a rotation crop, hence, the importance of its central location.

The structure is made of peeled round pine and fir logs, and the only manufactured lumber therein is the rough board sheeting used for roof boards, the wall plates and the cedar shingles with which it is covered, Using such material, it is possible for the Montana farmer, who is conveniently located to the mountains, to secure important buildings at a comparatively small outlay for material.

Diversified farming can never be exploited to advantage in Montana in the absence of suitable farm structures, and it is believed that in this way many can secure these much needed improvements, who would otherwise not be able to build.

315 rods of Kitselman woven wire fence have been built. The extreme height of this fence is 52 inches, but in pastures intended for sheep it has been thought wise to set posts 8 feet apart and 63 inches high, and to stretch above the woven fence, two strands of thick set barbed wire, thus making it impossible for dogs or wolves to jump into the enclosure.

Sheep feeding corrals have been constructed with fences of the same material and height. We now have fair facilities for conducting sheep and swine feeding experiments.

100, 2 year old wethers were fed in these sheep pens at a small profit the past winter. It was not thought best to bulletin the results, but to repeat the experiment under more careful management.

Among other buildings inherited by the Station from Gallatin County, was a single story frame building 23x45 feet, when constructed in 1890, this was set upon the ground, and sills and joists were found to be badly decayed in 1896. At an expense of $96, this was moved 100 feet, raised 7 feet, set upon 6 inch square pine posts, (these resting upon flat stones) and the story thus formed, was enclosed with peeled pine logs. This has been sub-divided into 9 pens for swine, the partitions also being of logs. We have thus secured a swine house adequate to present needs at a low cost.

A smoke house 16x16x12 feet has also been constructed of logs, (at a cost of $100). Farmers who are raising pork, find such a structure a great convenience, not only for curing and smoking meats required for home consumption, but if, in case the market for live or dressed pork is not satisfactory, they can easily convert the same into bacon, and smoked ham and shoulders, and hold these until the market is propitious for a sale.

PLAT GRAINS.

There was the usual number of small plats to grains and root crops.

This is a work that must cover a long series of years to arrive at valuable results. Eventually it is expected that safe, reliable information will be gained as to the performance of the different varieties of these crops, and selections made for more extended production of the best in order that the Montana farmer, who desires to co-operate with the Experiment Station, can be supplied with pure seed of desirable sorts, sufficient in quantity to start him in securing a reliable desirable seed supply.

The mountain states, with their extensively dry atmosphere, demand pure unmixed seed, seed grain that will mature evenly, otherwise the loss from irregular ripening and shelling of grain will be great. It is to-day practically impossible to procure in quantity pure unmixed seed grain. We must, therefore, depend largely upon our own resources in securing pure seed, adapted to our wants.

ROTATION TESTS.

Conditions in this agriculturally young state vary greatly from those where agriculture has been a leading industry for from 50 to 200 years; not only from the principal fact that farm operations are here of comparatively recent inauguration, but from the many complex propositions arising from the physical peculiarities of soil, and the general use of water for irrigation in cropping. There is a marked tendency each season to increase the area to farm crops, and to lessen the amount of fallow land.

Farmers are rapidly learning that unproductive land is expensive land, and that it requires one good farm to maintain another in idleness. Constant grain occupancy is as criminally wasteful as is summer fallowing, and to determine suitable crops to succeed each other is proper experiment work. Much of this kind of work has been done at older stations, but usually the small plat system has been employed. In this the constant tendency is to resort to more intensive methods than are practicable or profitable upon the farm, with misleading results. To avoid this difficulty a six years' rotation test was inaugurated in the spring of 1897 as follows :

Six representative acres were selected, lying side by side in a prominent part of the Station farm. These were accurately measured and fitted for crops in a good and workmanlike manner. Beginning upon the east side of the tract was sown 1 acre of Canada field peas. Next an acre to two rowed barley. Next an acre to sugar beets. Next an acre to oats. Next an acre to medium red clover. Next an acre to spring club wheat.

This land received a light top dressing of barnyard manure in 1896, and the bulk of it had produced a crop of hard fife wheat the same year averaging about 20 bushels per acre. It is proposed to shift these crops each year one space so that at the end of the rotation test the same crops will occupy the same positions that they did in the beginning of the experiment.

No manure or fertilizer will be used during the life of the experiment. If, as we expect it will, it develops at the end of the 6th year test, that the annual yields have been as good or a little better, each year than it was the previous season, it will have been fairly well demonstrated; first, that the rotation as planned was a wise one; second, that it is folly to have lands lying idle if they can be made to yield profitable continuous crops.

General intelligent crop rotation will change, in toto, two systems; first, that of summer fallow; second, that of exclusive small grain farming.

It is obviously out of the question to find a foreign (off the farm) market for crops such as clover, field peas and root crops. If the farmer uses them in rotation he must of necessity convert them into more concentrated products, such as pork, beef, mutton, poultry or dairy products.

It may not be wisdom to grow the sugar beet as a rotation crop, certainly not in advance of factories in which they can be converted into sugar, but there are other root crops that are profitable either on or off the farm, with the live stock attachment, which must complement small grain in diversified farming. We shall be greatly disappointed if close attention is not paid to the result of these rotation tests by Montana farmers.

STATION FARM CROPS.

Taking the position, upon the question of summer following, that the Station does, namely : that it is not a profitable procedure, comparisons have been made from year to year between the Station crops and those of Gallatin county.

The following are the averages of the Station farm crops for 1896 :

Barley, 54 bushels per acre.
Oats, 43 bushels per acre.
Spring wheat, 26 bushels per acre.
Field peas, 33.6 bushels per acre.

The following are the 1896 averages for Gallatin county :

Barley, 47.5 bushels per acre.
Oats, 54.8 bushels per acre.
Spring wheat, 34.2 bushels per acre.
Field peas, 19.2 bushels per acre.

In instituting this, a comparison between Station farm yields and those of Gallatin county those who are acquainted with the Station farm know that it is not a fair average of Gallatin county lands; also that the crops which have made Gallatin county famous have been produced on summer fallow lands.

We are convinced that for a certain period heavier yields can be produced under good summer fallow farming than in continuous cropping, but not enough better to warrant pursuing this system which compels the use of from fifty (50) to one hundred (100) per cent. more land to secure the same results, than would result if a good rotation of crops was adopted. Then, too, it is undeniably true that lands which lie bare through the major portion of the season sustain ultimately heavy losses of valuable chemical constituents and humus.

One item in these figures is worthy of attention : the Station barley yield. This is thirteen and seven-tenths per cent. (13.7) heavier than that of the county at large.

Upon the Station farm it has been concluded that it is good policy to sow barley on land that grew peas the preceding year. We think it is the common practice with farmers to sow barley upon summer fallowed land. This being the case, evidently lands which have produced a good crop of peas the previous year offer better conditions for a No. 1 barley crop than do fallowed lands.

Those accustomed to feeding field peas to live stock, will testify to their value for this purpose, and if yields equaling the Station farm yield, thirty-three and five tenths (33.6) bushels can be grown on lands which otherwise would produce nothing under the fallow system, it surely would pay to grow such a crop. Pea straw cut at the right season and properly cared for, is a desirable winter forage plant, and peas ground are more valuable as stock food for farm animals than corn or wheat, pound for pound. The Station yield of peas, which is 75 per cent. heavier than the average of the county yield, can be attributed to three causes.

First. Upon the Station farm, the Canadian pea is a leading crop. It is planted as early as possible, in well fitted land, with a drill, at the rate of two bushels seed per acre, at a depth cf 4 inches and receives two irrigations. Many farmers sow peas late, broadcasting the seed and harrowing in. Sown in this manner, one must be an expert to secure a good stand, germination is not uniform, and most important of all, the late shallow seeding places the plant at the mercy of the hot drying winds of early summer.

Second. But little prominence is given this crop, and it does not receive the same relative care on the average farm that we give it at the Station, with the result that general returns do not compare with Station yields.

Third. A number of the most successful farmers in Gallatin county grow peas exclusively for swine. When sufficiently matured, they turn swine into the fields and "hog them off"; such crops do not show in our returns, otherwise the general yield would be much heavier than it appears to have been. This plan of harvesting this crop with swine is, no doubt, satisfactory to those pursuing it, but it is after all an expensive way, and from limited enquiries made, we are of the opinion that they do not get the value from the crop that they would if the crop was regularly harvested. We find that to be as careful as we may in harvesting small grain, that the loss from shelled and shattered small grain, especially wheat, is a considerable per cent. of the whole crop, and that, as a rule, there will be sufficient of this ordinarily wasted grain to supply the needs of a moderate herd of swine, between the times of harvest and fall plowing. Great difficulty, too, is experienced in cutting a heavy crop of peas.

Tolton Bros., Guelph, Canada, have an attachment to mowing machines which has proved to be eminently satisfactory. It consists of a series of guards which keeps the vines off of the sickle bar of the mower, thus giving the sickle free play and a chance to cut the vines without clogging the sickle. This attachment makes it possible to shave the vines closely to the ground, leaving the land free of stubble.

In comparing wheat yields, it is fair tc state that the difference of more than 20 per cent. between the farm and county yields is due, in part, to the fact that a large per cent. of the spring wheat grain in Gallatin county is spring club, while spring fife was the Station farm crop, and as spring club is a heavier yielder than spring fife, it would be expected that the general yield would, therefore, exceed that of the Station.

FARMERS' INSTITUTES.

Meetings were held at Chinook, Fort Benton, Great Falls, Livingston, Big Timber, Laurel, Billings, Joliet, Red Lodge, Bozeman and Plains.

The fcllowing were some of the subjects discussed thereat:—

"Dairying;" "Swine Growing and Feeding;" "Sheep Feeding;" "Irrigation and Water Measurement;" "Poultry;" "Orcharding;" "Small Fruits;" "Canada Field Peas;" "Smuts of Grains;" "Scab of Potatoes;" "Injurious Insects;" "Alkali Soils;" "Relative Value of Foods;" "Home Life on the Farm;" "Agricultural Education;" "The Agricultural College;" "The Experiment Station and its Relations to the Farmer;" "Domestic Economy;" "Good Roads." Associated in this work with the Director were Drs. Traphagen and Wilcox, Prof. Beach, W. H. Sutherlin, Prof. W. L. Carlyle. of Minnesota, Prof. W. H. Williams, President James Reid, Mrs. Julia H. Emery and R. N. Sutherlin. Valuable aid was also received from able local speakers at the majority of the towns where meetings were held, as also by Institute Committees of Arrangement and Program. This important work is new in Montana, and is not, perhaps, as fully understood as it should be to insure the best results from institutes. These bear the same relation to agricultural communities that the Teachers institutes do to the cause of education. The benefits, if any, inure to communities from either of these educational efforts from the interchange of intelligent ideas and their application to the work in hand.

Farmers Institutes are valuable, where say, half a dozen progressive farmers are interested attendants upon the sessions and who carry to their homes and put into successful operation, worthy suggestions there received; others note their successes or failures and govern themselves accordingly, and thus improved farm methods become contagious in a way. This, however, is not the better way. There is a stimulus in numbers to any speaker or platform worker that comes from no other condition. Meetings are usually planned to be held at common centers readily accessible to farmers, and it is the plain duty of all such, as well as business men and their families to drop all other preventive business and attend each and every session.

Conducting and assisting in Farmers Institutes is outside of the regular paid duty of Station staff members, and of the Agricultural College Faculty. Such service is voluntary and gratuitous, and is always performed at great sacrifice to those therein engaged.

The difficulty and weariness of unaccustomed railway and stage travel are involved, proper work is temporarily neglected, to be made up later, at great cost, and the effort required, entitles workers to the fullest of attendance and the heartiest of support, from every man and woman who have the best interests of the community at heart. We undertake these institutes for two reasons.

First. We believe they are helpful to the cause of Montana agriculture.

Second. The information as to the country, the farmers and business generally, is valuable to our men, and supplies correct ideas as to the agricultural wants of Montana. Except for the generosity and good feeling shown toward the work by the following railway companies, the Northern Pacific, the Great Northern, and the Canada and Great Falls lines, it would have been impossible to conduct these meetings, and proper thanks are hereby tendered them in the name of the farmers of Montana, and of the Experiment Station and the Agricultural College. It is also generally understood that no funds are provided this institution by the national government, to defray the incidental expenses of the work, and that it is legitimate and necessary for communities to raise needed funds to conduct these meetings. In some states provision is made by due appropriation to carry on such work; in others it is the custom to raise Institute funds by private subscription. Business men do not always understand their full duty to the Institutes.

In up to date communities it is the custom to close all places of business for afternoon sessions at least, giving all full opportunity to pay the Institute undivided attention, instead of keeping open and running counter attractions to the meetings. If these meetings possess value, the merchant will ultimately receive his share, and it is his manifest duty to render the fullest co-operation.

Hereafter the Experiment Station, in justice to itself, cannot be a party to this work, in any community, without it being first pledged the heartiest support of farmers and business men.

NEWSPAPER EXCHANGE LIST.

In looking through the columns of the Press of the United States, one sees many extracts from bulletins and the pen of Station workers. This is especially true of the Agricultural Press. We appreciate this free use of Station literature as it is the very best method of informing the public of the result of experiment work.

Our Station staff receives, in the course of a year, many requests for special communications upon agricultural topics, and such are always freely honored. The law creating Stations makes it mandatory on them to mail copies of all bulletins to the Press of the State, and this is always done so far as we possess knowledge of the existence of the various publications. We know of no better way by which this information can be carried to the Station, than for publishers to mail regularly to the Experiment Station their publications, in exchange for the Station Bulletins. Many valuable suggestions, as to our work, came to us through the Press, and we are grateful to the publishers of the following papers and magazines for free copies:

The Quotation, St. Paul, Minn.
The Dorset Quarterly, Washington, Penn.
Utah Church and Farm, Salt Lake City, Utah.
The Wool Record, N. Y.
The Dixie Miller, Nashville, Tenn.
Lake City Republican, Lake City, Minn.

The World, Vancouver, B. C., Can.
The Great Falls News, Great Falls, Mont.
The Poultry Farmer, Des Moines, Iowa.
The Pacific Poultryman, Tacoma, Washington.
The Forester, Washington, D. C.
The Poultry Herald, St. Paul, Minn.
The Feather, Washington, D. C.
Oregon Poultry Journal, Salem, Ore.
The Poultry Monthly. The Ferris Pub. Co., Albany, N. Y.
Intermountain Poultry Journal, Rockford, Washington.
Farmers' Guide, Huntington, Ind.
Great Falls Weekly Tribune.
Livingston Enterprise.
The Milwaukee Journal.
Stock Growers Journal, Miles City, Mont.
Big Timber Pioneer.
The Dillon Examiner.
Yellowstone Journal, Miles City.
The Dillon Tribune.
Belt Valley Times.
Billings Times.
Livingston Herald.
The Western News, Hamilton, Mont.
Red Lodge Picket.
The Billings Gazette.
Livingston Post.
The Lewistown Democrat.
Madisonian, Virginia City, Mont.
The Northwest Tribune, Stevensville, Mont.
The Chinook Opinion.
Cotton Planter's Journal, Memphis, Tenn.
The Riverside, Red Wing, Minn.
The Farmers' Call, Quincy, Ill.
How To Grow Flowers, Springfield, Ohio.
The Irrigation Age, Chicago.
Farm Students' Review, St. Anthony Park, Minn.
The Agricultural Student, Columbus, Ohio.
College Exponent, City.
The Industrialist, Manhattan, Kan.
The Farm Journal, Philadelphia, Penn.
The Northwest Magazine, St. Paul, Minn.
Western Mining World, Butte, Mont.
The Park and Cemetery, Chicago.
The Farm and Poultry, Boston, Mass.
The Strawberry Culturist, Salisbury, Md.

The American Florist, Chicago.
West Virginia Farm Review, Charlestown, West Virginia.
The Horticultural Visitor, Kinmundy, Ill.
Green's Fruit Grower, Rochester, N. Y.
The Gentleman Farmer, Chicago, Ill.
Holstein Friesian Register, Brattleboro, Vermont.
The Jersey Bulletin, Indianapolis.
Farmers' Magazine, Springfield, Ill.
Hoard's Dairyman, Fort Atkinson, Wis.
Montana Fruit Grower, Missoula.
The Ruralist, Federalsburg, Md.
North American Horticulturist, Monroe, Mich.
Western Fruit Grower, St. Joseph, Mo.
Success With The Garden, Reed City, Mich.
Florists' Review, Chicago.
Stockman and Farmer, Helena, Mont.
Gardening, Monon Building, Chicago, Ill.
Home and Garden, St. Paul, Minn.
The Southern States and Farm Magazine, Baltimore, Md.
The Elgin Dairy Report, Ill.
Field and Farm, Denver, Col.
Farm News, Springfield, Ohio.
The Prairie Farmer, Chicago.
Oregon Agriculturist, Portland, Ore.
Wallace's Farmer, Des Moines, Iowa.
The Agricultural Epitomist, Indianapolis.
Home and Farm, Louisville, Ky.
Farm and Home, Springfield, Mass.
The North West Farmer, St. Paul, Minn.
The Nebraska Farmer, Omaha, Neb.
Rural New Yorker, New York.
Breeder's Gazette, Chicago.
Farmer's Voice, Chicago, Ill.
The Wisconsin Agriculturist, Racine, Wis.
The Northwestern Agriculturist, Minneapolis.
Farm, Stock and Home, Minneapolis.
The Homestead, Des Moines, Iowa.
Farming, Toronto, Can.
Butcher's Advocate, N. Y.
Orange Judd Farmer, Chicago, Ill.
The National Stockman and Farmer, Pittsburg, Penn.
The Poultry Keeper, Parkesburg, Penn.
Helena Independent.
The Inter-Mountain.
Anaconda Standard.

Democrat Messenger, Missoula, Mont.
The Daily Missoulian.
The Inter-Lake, Kalispell, Mont.
Avant Courier, Bozeman, Mont.
Bozeman Chronicle.
Baltimore Weekly Sun, Baltimore, Md.
Carbon County Sentinel, Gebo, Mont.
Weekly Tribune, Butte.
Jefferson County Sentinel, Boulder, Mont.
The Glendive Independent, Glendive, Mont.
The Mississippi Valley Lumberman, Minneapolis, Minn.
The Northwestern Agriculturist, Minneapolis, Minn.

DONATIONS.

The Station makes due acknowledgment of the following gifts:

Leber & Meyer, New York city 1 sample Wohanka sugar beet seed.

W. Atlee Burpee & Co., Philadelphia, Pa., 33 packages, flower and garden seeds.

U. S. Botanic gardens, Washington, D. C., 17 packages tree and plant seeds.

W. H. Heidemann, Kalispell, Mont., 1 package wild black cap raspberry seed.

C. D. Thompson, Oregon, 1 package Oregon everbearing strawberry plants.

D. A. Richardson & Co., Faribault, Minn., 7 packages flower and vegetable seeds.

E. W. Allen, Wolverton, Minn., 5 one pound packages potato seed.

Geo. S. Josselyn, Fredonia, N. Y., 1 Campbell's early grape vine.

Kitselman Bros., Ridgeville, Indiana, 1 Duplex fence weaving machine.

DISCOUNTS.

The A. B. Farquhar Co., York, Penn., a handsome discount from jobbing prices upon 1 low down Vibrator threshing machine, with a stated capacity of 500 bushels of grain per day; this machine threshed 1,200 bushels barley per day in a most satisfactory manner.

BULLETINS.

Four Bulletins have been issued for the present fiscal year. Bulletin 13, Drinking Waters, 16 pages, 6,000 copies, by F. W. Traphagen; Bulletin 14, Montana Swine Feeding, 20 pages, 6,000 copies, by Frank Beach; Bulletin 15, Larkspur Poisoning of Sheep, 22 pages, 6,000 copies, by E. V. Wilcox. These, with this annual report, as Bulletin No. 16, 54 pages, 6,000 copies, constitute the legal number required under the Hatch law. The Bulletins of this Station are in urgent demand, and it is only a question of time when the State of Montana must lend assistance in the publication of the annual Bulletins, Montanans are a reading people, and the ratio of Bulletins published to the population of the State, is greater than that of any other State in the Union.

Respectfully Submitted,
S. M. EMERY, Director.

STRAWBERRIES.

Various points of interest in connection with strawberry culture have been considered, among these the yield of a bed, in its second fruiting year, as in comparison with the first or the third year from planting as compared from the second year from planting. There is much difference of opinion between growers as to the relative value of strawberry beds after their first fruiting year. Peter Henderson, early advised planting in pots; transplanting from these into fruiting beds the same season they were grown; giving a high state of culture; ample winter protection, and after the first crop of fruit, to plow up beds; depending entirely upon potted plants for fruiting plants. This no doubt is good theory from the nurseryman's standpoint; the usual price for potted plants being $50 per thousand. This may be classed as the views of an extremist. In eastern states the general concensus of opinion among the best growers, varies only as to the length of time after the second full crop is secured, before the bed should be plowed up and new plantations set. Many insist that the first crop, i. e., the second year from planting; is the only paying crop, others the first and second, and as a general thing, all agreeing that the third crop is the ultimate one that can be grown with profit. We do not agree with either of these theories but believe, that given fairly good land, plenty of manure, and an abundance of moisture, applied at proper time, that beds may be maintained with profit, almost indefinitely, under a good system of cultivation.

Desiring information on this subject, our beds were given thorough cultivation in '96 following fruiting with a single horse cultivator; all weeds, grass, etc., that could not be reached by cultivator were hand pulled.

Well rotted manure applied at the rate of 750 bushels per acre. This was applied with a Kemp & Burpee manure spreader, broadcast over the beds, fertilizing not only between the rows but on and about the plants as well. Well rotted barn-yard manure was that used and it was immediately well cultivated into the soil between the rows. The water then was turned on; as much as the land would absorb.

Prior to this time the new plants and runners (which start very early under irrigation, frequently in July) had well occupied all the space between the rows, and as a result of the merciless cultivation many of the young plants were uprooted or entirely destroyed. No attention, however, was paid to this condition, and under the revivifying effects of cultivating, fertilizing and irrigating, they speedily resumed growth, and early fall, found the beds well furnished with strong vigorous plants.

In December the beds were mulched with straw, this remained until April, this operation having been postponed as long as possible in order to retard the bloom period.

Beginning April 10th and extending as late as May 26th, plants were dug for sale. These were supplied to all wishing them at 30 cents per hundred or $5 per thousand plants. The difference in price to encourage numerous small orders rather than large wholesale orders. (Plants will be supplied this year at the same rate, cash accompanying the order, the selection of varieties being left to the Experiment Station).

The accompanying list shows the number of plants dug from each variety, this varies from thirty-one plants of the Brandywine, up to 305 of Barton's Eclipse. This list is interesting in connection with the tables showing the amount of fruit picked from each variety:

Number of plants dug, spring 1897, from beds of 25 plants, set spring, 1895.

Variety.	Number.	Variety.	Number.
Arrow	150	Ivanhoe	207
Belmont	100	Klickitia	127
Belle	150	Leader	100
Bisel	265	Lovett	97
Brandywine	31	Michel's Early	85
Bubach No. 5	225	Meek's Early	75
Barton's Eclipse	305	Muskingum	75
Beverly	175	Mrs. Cleveland	75
Bederwood	90	Princess	175
Crescent	196	Princeton Chief	150
Cyclone	125	Paris King	66
Columbian	250	Robinson	147
Dayton	100	Shuster Gem	100
Enormous	79	Sharpless	25
Enhance	72	Stayman No. 1	97
Edgar Queen	150	Splendid	265
Governor Hoard	184	Swindle	50
General Putnam	25	Tennessee Prolific	164
Greenville	125	Victor Hugo	175
Gandy Belle	106	Warfield	150
Great Pacific	175		
Gandy	25	Plants Dug	5668
Haverland	135	Originally Set	1450

In digging it was the intention to leave each variety with a good supply of strong, vigorous fruiting plants.

It is to be remembered that of each variety 25 plants were originally set in '95, exceptions to this were Haverland, Bederwood, Crescent and Michel's early, of these sorts 500 plants were set, but in all estimates of plants dug and fruit harvested these varieties were averaged so as to place them upon the same numerical footing as the other varieties.

After removing the straw in April, the cultivator was run through the rows so as to level up from the effects of digging plants, the weeds were pulled, the straw replaced between the rows, and the bed lightly irrigated.

Field notes were taken as to the date of the appearance of first bloom, the first fruiting, the amount of fruit produced by each variety; also the following comparisons, the relative bloom and fruit periods of '96 and '97; also the fruit yields of '96 and '97.

STRAWBERRY LIST.

VARIETY.	First bloom '97......	First bloom '98......	Difference bloom period............	First fruit '97........	First fruit '98....	Difference fruit period..............
Arrow P.	5-29	6 12	14 Days	6-27	7-9	12 Days
Belmont S.	5-29	6-14	16 “	7-6	7-11	5 “
Belle S.	5-28	6-16	19 “	7-10	7-15	5 “
Banquet S.	6-2	6-16	14 “	7-4	7-13	9 “
Bisel P.	5-27	6-14	18 “	7-2	7-6	4 “
Brandywine S	5.26	6-21	26 “	7-1	7-17	16 “
Bubach No. 5 P.	5-25	6-15	21 “	6-23	7-8	15 “
Barton's Eclipse P.	5 25	6-9	15 “	6-30	7-9	9 “
Beverly S.	5-19	6-14	26 “	6-23	7-7	14 “
Bederwood S.	5-19	6-10	22 “	6-21	7-5	14 “
Crescent P.	5-19	6-9	21 “	6-22	7-5	13 “
Cyclone S.	5-24	6-13	20 “	6-21	7-8	17 “
Crawford S.	5 25	6-15	21 “	6-24	7-8	14 “
Columbian S.	5 31	6-15	15 “	7-4	7-10	6 “
Chair's S.	6-1	6-15	14 “	7-4	7-10	6 “
Dayton S.	5-19	6-8	20 “	6-22	7-6	14 “
Enormous P.	5-31	6-16	16 “	7-4	7 9	5 “
E. P. Roe S.	5-19	6 12	24 “	6-30	7-12	12 “
Eureka S.	5 24	6-12	19 “	6-24	7-11	17 “
Enhance S.	5-19	6-9	21 “	6-29	7 9	10 “
Edgar Queen P.	5-28	6-14	17 “	7-2	7-8	6 “
Governor Hoard S.	5 19	6-12	24 “	6-21	7-10	19 “
Gillespie S.	5-21	6-13	23 “	6-24	7-11	17 “
General Putnam P.	5-24	6-9	16 “	7-2	7-10	8 “
Greenville P.	5-27	6-12	16 “	7-1	7-11	10 “
Gandy Belle S.	5-29	6-12	14 “	6-21	7-9	18 “
Great Pacific P.	5-30	6-15	16 “	7-2	7-9	7 “
Gandy S.	6-1	6-19	18 “	7-10	7-13	3 “
Haverland P.	5-19	6-8	20 “	6-19	7-6	17 “
Hoffman S.	5-25	6-14	20 “	6-21	7-8	17 “
Ivanhoe S.	5-27	6-14	18 “	7-1	7-5	4 “
Jay Gould P.	6-5	6-19	14 “	7-2	7 13	11 “
Klickitia P.	5-24	6-11	18 “	7-4	7-10	6 “
Leader S.	5-24	6-9	16 “	6-22	7-8	16 “
Lovett S.	5-21	6-13	23 “	6-21	7-5	14 “
Michel's Early S.	5-18	6-7	20 “	6-15	7-4	19 “
Meek's Early S.	5-24	6-16	23 “	6-21	7-8	17 “
Muskingum S.	5-30	6-15	16 “	6-29	7-11	12 “
Mrs. Cleveland P.	5-30	6-15	16 “	7-4	7-9	5 “
Princess P.	5-30	6 13	14 “	6-30	7-11	11 “
Princeton Chief P.	5-30	6-15	16 “	7-10	7-12	2 “
Parker Earl S.	5-25	6-12	18 “	6-27	7-11	14 “
Paris King S.	5-21	6-12	22 “	6-22	7-5	13 “
Rio S.	5-22	6-15	24 “	6-25	7-10	16 “

STRAWBERRY LIST, (Continued.)

VARIETY.	First bloom '97	First bloom '96	Difference bloom period	First fruit '97	First fruit '96	Difference fruit period
Robinson S	5-24	6 12	19 "	6-25	7-6	12 "
Sandoval S	5-25	6-16	22 "	7-6	7-13	7 "
Stevens S	5-30	6 12	13 "	7-2	7-6	4 "
Shuster Gem P	5-30	6-12	13 "	6-28	7-10	17 "
Sharpless S	5-24	6-13	20 "	6-29	7-11	12 "
Stayman No. 1 P	5-24	6-12	19 "	6-21	7-6	15 "
Splendid S	5-21	6-14	24 "	6-21	7-10	19 "
Swindle P	5-19	6-12	24 "	6-21	7-9	18 "
Timbrell P	5-20	6-8	19 "	7-1	7-15	14 "
Tennessee ProlificS	5-30	6-9	10 "	7-2	7-8	6 "
Victor Hugo S	5-30	6-12	13 "	7-4	7 10	6 "
Van Deman S	5-20	6-8	19 "	6-21	7-5	14 "
Wilson's Albany S	5-31	6-12	12 "	7-4	7-9	5 "
Warfield P	5-19	6-9	21 "	6-22	7-5	13 "

STRAWBERRY LIST.

VARIETY.	Yield fruit '97, lbs. and oz.	Yield fruit '96, lbs. and oz	Increase yield '97 over '96, lbs. and oz.	Decrease yield '97 from '96, lbs.-oz.
Arrow P	2-4	5	....	2-12
Belmont S	9-5	7-13	1-8	....
Belle S	18-2	8-4	9-14	....
Banquet S	7-8	2-10	4-14	....
Bisel P	46-0	27-11	18-5	....
Brandywine S	8-1	10 Brs.	....	....
Bubach No. 5 P	31-14	7-5	24-9	....
Barton's Eclipse P	16-5	12-5	4-	....
Beverly S	22-2	11-5	10-13	....
Bederwood S	37-5	17-11	19-10	....
Crescent P	22-6	13-8	8-14	....
Cyclone S	21-6	22-7	....	1-6
Crawford S	12-10	6-4	6-6	....
Columbian S	7-5	3-14	3-7	...
Chair's S	12-0	2-8	9-8	....

STRAWBERRY LIST, (Continued.)

VARIETY.	Yield fruit '97, lbs. and oz..........	Yield fruit '96, lbs. and oz..........	Increase yield '97 over '96, lbs. and oz	Decrease yield '97 from '96 lbs.-oz..
Dayton S.	10 13	5-6	5-7	....
Enormous P.	37-5	15-0	22-5	....
E. P. Roe S.	11-0	5-6	5-10	....
Eureka S.	32-15	6-12	26-3	....
Enhance S.	39-8	24-2	15-6	....
Edgar Queen P.	10-10	10-13	....	-3
Governor Hoard S.	17-14	12-6	5-8	....
Gillespie S.	8-9	2-1	6-8	....
General Putnam P.	6-13	4-1	2-12	....
Greenville P.	8-12	8-3	-9	....
Gandy Belle S.	33-2	19-7	13-11	....
Great Pacific P.	7-0	2-10	4-6	....
Gandy S.	12-9	4-10	7-15	....
Haverland P.	20-5	3-15	16 6	....
Hoffman S.	8-10	4-6	4-4	....
Ivanhoe S.	32-12	16-7	16-5	....
Jay Gould P.	8-10	1-13	6-13	....
Klickitia P.	15-11	13-15	1-11	....
Leader S.	21-6	7-11	13-11	....
Lovett S.	24-2	22-1	2-1	....
Michel's Early S.	24-0	2-11	21-5	....
Meeks Early S.	1-13	-7	1-6	....
Muskingum S.	14-14	3-13	11-1	....
Mrs. Cleveland P.	22-8	8 6	14-2	....
Princess P.	25-3	9-4	15-15	....
Princeton Chief P.	14-5	4 8	9-13	....
Parker Early S.	12-14	3-6	9-8	....
Paris King S.	16-15	17-9	....	-10
Rio S.	20-0	1-2	18-14	....
Robinson S.	23-9	14-7	9-2	....
Sandoval S.	9-12	4-3	5-9	....
Stevens S.	1-12	1-14	....	-2
Shuster Gem P.	16-13	5-13	11-0	....
Sharpless S.	15-7	6-5	9-2	....
Stayman No. 1 P.	42-14	21-8	21-6	....
Splendid S.	54-8	22-9	31-15	....
Swindle P.	22-3	13-2	9-1	....
Timbrell P.	11-14	4-7	7-7	....
Tennessee Prolific S.	20-10	16-6	4-4	....
Victor Hugo S.	10-9	4-5	6-4	....
Van Deman S.	17-9	5-15	11-10	....
Wilson's Albany S.	10-15	-13	10-2	....
Warfield P.	34-3	16-14	17-5	....

These tables are interesting and will bear analysis. It also justifies the belief that a strawberry bed of good varieties, under proper cultivation and irrigation, will out-last by many years the general lifetime of unirrigated beds.

The average gain in yield of the crop of '97 over that of '96, considering only those varieties which gave an increased yield, was ten pounds ten ounces to 25 plants as set in '95.

Ordinarily it is not deemed a wise plan to disturb the soil in or about fruiting beds, and there is shown by the tables a very interesting relation between digging plants and the fruiting capacity of the beds thus disturbed. The general average of plants dug, was 131; among varieties equal or exceeding the average increase in yield of ten pounds ten ounces, from which 131 or more plants were dug are the following:

Variety.	No. Plants dug.	Increase in yield in '97 over '96.	
		Pounds.	Ounces.
Bisel	265	18	5
Bubach, No. 5	225	24	9
Beverly	175	10	13
Haverland	135	16	6
Ivanhoe	207	16	5
Princess	175	15	15
Splendid	265	31	15
Warfield	150	17	5

This result proves that the best results in a fruiting bed are not to be gained, unless cultivation is given the bed.

Fear was expressed by the workman in charge of the work, an old experienced strawberry culturist, that the beds had been dug altogether too closely, and that the result would be loss in impaired fruiting.

The fruit yield table affords an interesting study presenting as it does a series of startling surprises, beginning with the old popular stand by, Michel's early, which in '96 yielded two pounds eleven ounces of fruit, among the very poorest this gave in '97, 24 pounds, thus justifying the wisdom of affording it a place in the beds. The gross yield for '97 was more than double that of '96, and is a striking endorsement of rich fertilization, good cultivation and frequent irrigation.

Nineteen varieties yielded over a half pound of fruit per plant in 1896. In '97 this number was almost doubled, 37 sorts showing this rate of yield.

Not a variety which yielded in the ½ pound class in '96, dropped below this in '97, and every variety showed a marked increase, this was notably so with Bisel, Bederwood, Crescent, Enormous, Enhance, Gov. Hoard, Gandy Bell, Ivanhoe, Robinson, Stayman No. 1, Splendid, Swindle, Tennessee Prolific and Warfield. Any of these sorts will prove valuable in localities similar to this.

A new list is now offered of plants which have exceeded 1 pound per plant of the parent plants set in '95. This is as follows:

Variety.	Pounds.	Ounces.
Bisel	46	11
Bubach No 5	31	14
Bederwood	37	5
Enormous	37	5
Eureka	32	15
Enhance	39	8
Gandy Belle	33	2
Ivanhoe	32	12
Princess	25	3
Stayman No. 1	42	14
Splendid	54	8
Warfield	34	8

It will carry more definite information to state that these are yields from 37 running feet of matted berry row, and that the same averag yield would give at the rate of about 10,000 pounds of fruit per acre.

This rate of yield has been exceeded only in exceptional cases. It would be easier to realize the same result in acre plats under thorough cultivation, than to duplicate these yields under existing conditions.

Time and again has the writer heard it claimed by nurserymen: "In digging plants from fruiting beds we cannot expect them to fruit freely."

We are convinced that had these beds been undisturbed in the spring and no plants taken from them, (which, of itself, is a thorough form of cultivation) and that the ground had not been abundantly fertilized and cultivated, that the yield would not have been nearly so great.

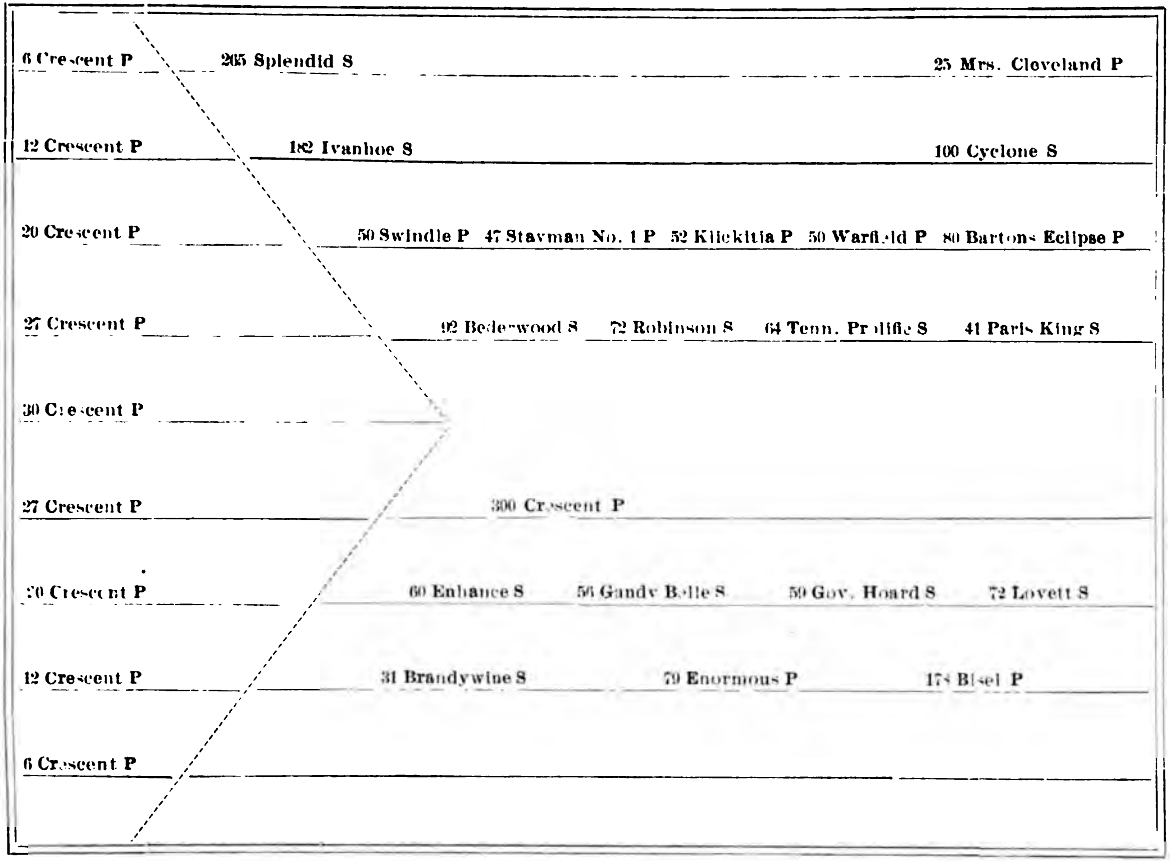
Irrigation was, probably, too freely indulged in to insure the best of flavor in fruit. Comparisons were made by ccmpetent authority between the quality of the crops of '96 and '97; also between the Station berries and the berries from neighborhood beds which were not so frequently irrigated. These comparisons were not to the credit of the '97 Station berries.

On an average, water was applied weekly through the fruiting season, one half of the bed being irrigated at a time, the water remaining on the bed over night. It is good practice in economizing water, and preventing the soil from washing, to mulch between the rows (which is usually the furrow through which the water passes). With a natural fall of 18 inches in a hundred feet, in our strawberry beds, the soil did not wash, a most important consideration in all crops grown under irrigation.

It is proposed, in the near future, to test the effect of irrigation upon flavor; chemical analysis will supplement natural methods in such determination.

It will be remembered that the present beds when set in '95 were planted regardless of sex or season for bloom. Believing that to get the very best fruiting effects from plants that reference should be had to these conditions, a new bed was set in the spring of '97, selections were made for the new bed of varieties which averaged ½ pound or more fruit per plant, associating together in the new beds staminate and pistillate varieties, also those having substantially simultaneous bloom periods. The arrangement of the new bed is shown by the diagram of the new bed set in '97, on page 78.

* * *



6 Crescent P 265 Splendid S 25 Mrs. Cleveland P

12 Crescent P 182 Ivanhoe S 100 Cyclone S

20 Crescent P 50 Swindle P 47 Stayman No. 1 P 52 Klickitia P 50 Warfield P 80 Bartons Eclipse P

27 Crescent P 92 Bederwood S 72 Robinson S 64 Tenn. Prolific S 41 Paris King S

30 Crescent P

27 Crescent P 300 Crescent P

20 Crescent P 60 Enhance S 56 Gandy Belle S 59 Gov. Hoard S 72 Lovett S

12 Crescent P 31 Brandywine S 79 Enormous P 178 Bisel P

6 Crescent P

A moot question among nurserymen is the proper proportion of pistillate plants to alternate with staminates to insure best fruiting results. It is conceded that a pistillate sort alternated with barely sufficient staminates to sufficiently fertilize is more productive than when there is an excess of the staminate kinds.

To afford means of study for this question a special bed has been set as follows: A triangle with a base 45 feet wide, and an apex 51 feet long, in which the rows run lengthwise 5 feet apart, has been set with Crescent seedling plants 18 inches apart in the rows. The Crescent plants cease where the sides of the triangle cut the rows, these rows are projected beyond this triangle and at the point where the Crescent cease, staminate sorts are set with but two exceptions. It is proposed to ascertain the relative fruitfulness of the individual Crescent plants within the triangle, as the distance from the pistillate to the staminate plants varies from eighteen inches to 22½ feet.

To determine this, each plant within the triangle will be numbered and a separate account taken of the fruit produced on it.

There will also be an attempt to gain light upon the question as to how the pollen is most commonly transferred from plant to plant, whether on the wind or by insects.

Protecting gauze screens will be placed over the blooming plants, the meshes being of such a size as to prevent the approach of insects. (See diagram of new bed, for plan of this bed, page 78.)

Two colonies of bees, on the Station farm, have added an effective host to the busy insect workers which frequented the berry patch when in bloom, and we attribute, to no small degree, the improvement in the fruit crop of '97 to the better pollenization of the blooms by the bees. These were not present in '96.

On June 11th a white frost occurred; ten days later we attempted to determine the extent of the damage.

The following was the method employed: beginning at a given point on each bed, 100 blooms were counted as they came (every stage of development of bloom or fruit entering into the calculation), and each bloom or berry, showing any injury was noted. We thus ascertained the exact number of damaged blooms or fruits out of each hundred consecutive blooms or fruits. The following table shows the amount of such injury:

Table of per cent. of blooms injured by frost on June 21st, 1897:

	Per cent.		Per cent.
Arrow	2	Hoffman	7
Belmont	3	Ivanhoe	2
Belle	5	Jay Gould	1
Banquet	5	Klickitia	3
Bisel	0	Leader	4
Brandywine	1	Lovett	6
Bubach No. 5	7	Michel's Early	8
Bartons Eclipse	3	Meek's Early	4
Beverly	1	Muskingum	11
Bederwood	6	Mrs. Cleveland	3
Crescent	0	Princess	3
Cyclone	3	Princeton Chief	0
Crawford	3	Parker Earle	0
Columbian	12	Paris King	3
Chair's	1	Rio	3
Dayton	3	Robinson	0
Enormous	1	Sandoval	2
E. P. Roe	5	Stevens	0
Eureka	2	Shuster Gem	0
Enhance	4	Sharpless	6
Edgar Queen	4	Stayman No. 1	2
Gov. Hoard	8	Splendid	2
Gillespie	6	Swindle	3
Gen. Putnam	0	Timbrel	3
Greenville	2	Tenn. Prolific	9
Gandy Belle	2	Victor Hugo	4
Great Pacific	1	Van Deman	2
Gandy	2	Wilson	2
Haverland	4	Warfield	0

It will be noted that the variation is wide, running from nothing in the cases of Bisel, Crescent, Gen. Putnam, Princeton Chief, Parker Earle, Robinson, Stevens, Shuster Gem and Warfield, up to as high as twelve per cent. of Columbian, and eleven per cent. of Muskingum, with an average of four per cent. for the whole of the damaged varieties.

The date of bloom period does not seem to have had much to do with the relative amount of injury.

Of those showing no injury, the Bisel, Gen. Putnam, Princeton Chief, Parker Earl, Robinson, Stevens, Shuster Gem are late or moderately late bloomers, while the Warfield is among the earliest of the bloomers.

The first bloom period of both the Columbian and Muskingum is the same, May 30th, and these might be classed with the late bloomers.

Among the very latest bloomers are:

Banquet........June 2d, five per cent. injury.
Chair's Seeding. June 1st, one per cent. injury.
Gandy..........June 1st, two per cent. injury.
Jay Gould......June 5th, one per cent. injury.

All of these, with one exception, Banquet, being much below the average of injury.

The period of examination was June 21st, and these early blooms had developed into berries the size of a large garden pea.

The apparent discrepancy in relative amount of injury excited suspicion and a partial investigation of the injured blooms and fruit with the aid of a microscope which magnified forty times was inaugurated to determine whether or no there was not a structural physiological difference in conformation not only of the bloom in early stages, but also of the immature fruit.

In this work Dr. E. V. Wilcox, biologist, afforded very material assistance, taking charge of this line of investigation.

Sufficient results were obtained to warrant farther and more extended investigations along these lines. Such will be conducted in '98. There is not a question of doubt but that there is a vast difference in the makeup of the different varieties of strawberry blooms and fruits in respect to frost resistance.

There is no section of country familiar to the writer in which strawberry blooms and late spring frosts are not contemporaneous, and the annual loss from this cause is much greater than is generally believed as the injured bloom or fruit rapidly dries up and disappears and is not long present as a mute reminder of the damage inflicted.

Doubtless no variety will be found that is wholly immune from frost effects, but we do think there are varieties better able to resist frost effect than others, and if this can be authoritatively determined, other things being equal, such varieties will prove very much more valuable for general propagation.

Dates of latest killing frosts for 9 years past at Bozeman, Mont:

1888. May 17, 25 degrees.
1889. May 17, 27 degrees.
1890. April 20, 25 degrees. (May 14, 30 degrees).*
1891. May 20, 26 degrees.
1892. May 14, 29 degrees.
1893. May 2, 27 degrees. (May 24, 30 degrees).*
1894. May 15, 29 degrees. (June 14, 30 degrees).*
1895. June 9, 28 degrees.
1896. May 25, 29 degrees.

** These dates marked * did not show serious injury to vegetation.

(We are indebted to Mr. Peter Koch, of Bozeman, for these frost records, he has preserved a weather record, which runs back many years).

No line of work undertaken upon the Station has excited the interest, as has that of the strawberry tests.

The comparative fruiting tests of the many varieties in '96 prepared our visitors for a closer inspection in '97, it was thought by many that the best possible results had been obtained in '96, but the common expression of those who saw the beds in '97 was, "we have never seen the like."

We desire to express our appreciation for the hearty sympathy and interest of visitors in the strawberry work.

There is nothing more tempting than large luscious berries doubly beautiful from their rich setting of green leaves, and from time immemorial people have been educated up to the belief that it is entirely proper to test them on the spot, and yet, there has not been the slightest difficulty for us to give the rightful impression, that the accuracy of results depended upon careful weights to a berry.

The fact that visitors were given full opportunity to sample the various kinds, after they were picked and weighed, doubtless had much to do with their forbearance.

Montana, from the many natural advantages, occupies the strong position of having the conditions that will enable her to grow better berries, that will be more salable than those from any other state.

Better soil for strawberries cannot be found on the globe. Irrigation is commonly practiced, and the irreverent have spoken of the strawberry as "sweetened water," but most important of all is the season in which Montana berries mature. Our best berries ripen after the rush is over from competing states, thus leaving a free and open market for Montana berries when in their best estate.

The strawberry is worthy of the attention of all fruit growers, and careful selection of varieties, coupled with conscientious cultivation, will bring speedier and more satisfactory returns than any other fruit.

THE EXPERIMENT ORCHARD.

Successful orcharding depends more largely upon natural conditions than does small fruit culture. From the very nature of things, it is not possible to extend to the orchard tree the perfect protection from sudden climatic changes, which may be given to the strawberry plant, and the bush vine or shrub of the currant, gooseberry and raspberry, and the blackberry or the grape. Three winters have intervened since the Station orchard was set and there has been, up to this writing (Feb. '98) but little actual difference in the winters, as indicated by an average of the temperature for the three seasons. Yet the amount of damage done to the trees in the season of '96 and '97, is relatively much greater, than was that of '95 and '96, or that promises to be in '97 and '98.

The loss the first winter was so slight as to be hardly worth noting, while the damage the second winter will aggregate fully 35 per cent. in trees originally set.

In following the annual record of the Station orchard, it is earnestly hoped that those interested will remember that the orchard is a trial orchard, and not such as would have been planted had it been set by the light of the best experience existing in Montana.

The majority of the trees set, were set to die, believing that if these sorts were set under the most favorable conditions for success, and that they succumbed to Montana climatic conditions, having been given a good show for their lives that planters in the state, who are practically similarly situated would refrain from setting such varieties in the future, and thus much substantial benefit ultimately accrue to the state by these experiments.

We think that as far as we have proceeded in this work that additional light can be given upon the important question—what to set in Montana; and this is or will be largely confirmatory of private experience, previously gained by practical growers of orchards in Montana.

Such a list is not a large one, and it is well that it is not, as the greatest obstacle to-day to the profit in orcharding from present investments just coming to fruiting is found, in the unpardonable multiplicity in fruiting varieties, making of many of the older orchards being a hodge podge of sorts, too few of which, will yield paying returns to the owners. This can be obviated in the future to an extent by top working, and thus effecting a change in the fruit.

Few realize, however, that the stock (namely, the root and stem of the tree to be thus altered) or foundation, for successful work, to give good results is a matter of as careful selection as is the new cion to be introduced to change the variety. To render the new venture successful the stock should be a clean, vigorous, healthy grower, free from taint or tendency to blight. It should possess a natural affinity for the variety to be grafted thereon.

For example, many years ago, it was thought that the wild crab as found growing in Minnesota and Wisconsin would make a good parent stock for the pear, and many were transplanted and top worked to pears. For a year or two, the work was highly successful, however, when the union was complete between stock and graft, and the pear began to realize all it could from the parent stock, it began to grow in a widely different ratio from the wild crab on which it was grafted, and became from two to four times larger than its supporting stem, and not having a natural support, many of the pear tops were broken off by their own weight.. This was an illustration of the importance of selecting stock and graft of equable habit of development.

The Transcendant and Virginia crabs make good stocks, the former is one of the most vigorous of growers, while the latter makes a more moderate development and is better suited to a cion of medium growth. Much the better way is for orchardists to confine plantings to a few well known, hardy, healthy, kinds of desirable season and quality.

The only winter protection employed in the Station orchard, is winding the stems of the trees from the ground tc the crotches with newspapers. The paper is secured at top, bottom, and midway with strings not too tightly drawn. The injury to trees was occasioned by an abnormally cold spell in November, the thermometer indicating 29° below zero. This spell came before the trees were protected and was quite fatal to many of the tender varieties.

In apples, the loss among Russian varieties is comparatively small, as will be seen by reference to the list. It does not follow, however, that these should be set indiscriminately, because, while there are some Russians of good quality, the majority are of very poor value for fruit.

Varieties doing well are, Longfield, Wealthy, Alexander, Okabena, Duchess, St. Lawrence, Yellow Transparent. Pewaukee, Gideon and Red Astrachan.

In Pears, these give good promise, Giffard, Flemish Beauty, Tyson, Boussock Doyenne Dete and Seckel.

The Crab Apples, Hislop, Transcendent, Greenwood, Martha and Early Strawberry, are alive and in a thrifty condition.

CHEMICAL LABORATORY, MONTANA EXPERIMENT STATION

Of Cherries nearly 50 per cent. are dead. The varieties that have suffered no loss are, Amarilla, Montmorency and E. Richmond.

In Plums the loss has been heavy, these varieties only having sustained no loss: Moldovka, Wild Goose, DeSota, Weaver, Bavay's Green Gage and Wyant.

In Prunes the loss is about 4 per cent.

It has been difficult to prevent over irrigation, and the irrigation season has been shortened each season until the past, when it ceased in July. Many make the serious mistake of substituting irrigation for cultivation. Orchards should receive frequent shallow clean culture through May, June and July. Cultivation and irrigation should then cease, except in exceptional instances, when such need can be determined by the appearance of the leaf and fruit.

GENERAL NOTES ON SMALL FRUITS.

Currants have done remarkably well, fruiting abundantly, and the fruit remains on bushes after ripening for weeks, if ungathered. The Fay's seedling has not succeeded well. It evidently is not so hardy as other varieties. Gooseberries have been a failure.

Dewberries (Lucretia and Windom) bloom freely, but the flowers appear to lack pollination, and the fruit comes to naught.

Blackberries are of no value on these grounds.

Comparative tests will be made later of the small fruits which are doing well and results noted.

The Station and College grounds are large and commanding, and tests are being conducted of the flowering roses and shrubs with the intention of propagating from such sorts as succeed well for ornamentation of the grounds. To date they are living and thriving with but few exceptions.

APPLE LIST.

Variety.	SET.	ALIVE.	DEAD.
Yellow Crimean,	5	5	0
Red Queen	6	6	0
Grandmother	5	3	2
Gipsy Girl	5	4	1
Bogdanoff	5	4	1
Persian	5	4	1
Royal Table	5	4	1
12 M.	5	4	1

Rambour Queen	5	4	1
No. 257	5	4	1
Borsdorf	4	2	2
Longfield	3	3	0
Wealthy	5	5	0
Alexander	2	2	0
Tetofsky	5	3	2
Arabskoe	2	1	1
Fameuse	2	2	0
Cross	1	1	0
Gideon	3	3	0
Veronesch	11	9	2
Anisette	4	3	1
Zuzoff	5	2	3
Aport	5	5	0
Baiken	5	4	1
Rosenhagen	5	3	2
Orel No. 11	5	5	0
Good Peasant	6	6	0
Lead 3 N	7	6	1
Walbridge	2	1	1
Northern Spy	2	0	2
Gravenstein	2	0	2
Veronesch, Rosy	3	3	0
Grime's Golden	2	1	1
Red Bietigheimer	2	2	0
Hurlbut	2	1	1
Fall Pippin	2	2	0
Ben Davis	1	1	1
Golden Russet	5	3	2
Keswick Codlin	2	2	0
Red Astrachan	2	2	0
Haas	3	1	2
Okabena	3	3	0
Thompson's	24	9	15
Sutton Beauty	2	2	0
Maiden Blush	2	2	0
Duchess	5	5	0
Scott's Winter	3	1	2
Wolf River	3	2	1
Hibernal	3	3	0
St. Lawrence	2	2	0
Talman Sweet	2	2	0
Yellow Transparent	2	2	0
Pewaukee	2	2	0
Total	214	161	53

PEAR LIST.

Variety.	SET.	ALIVE.	DEAD.
Giffard	2	2	0
Frederick Clapp	2	1	1
Flemish Beauty	2	2	0
Tyson	2	2	0
Winter Nelis	2	1	1
Anjou	2	1	1
Boussock	2	2	0
Doyenne d Ete	4	4	0
Augouleme	2	1	1
Sheldon	2	0	2
Seckel	2	2	0
Lawrence	2	1	1
Total	26	19	7

CRAB APPLES.

Variety.	SET.	ALIVE.	DEAD
Pride of Minneapolis	3	1	2
Whitney	5	4	1
Hislop	2	2	0
Transcendent	5	5	0
Greenwood	3	3	0
Bailey's Crimson	3	1	2
Martha	3	3	0
Virginia	3	3	0
Orange	3	2	1
Early Strawberry	3	3	0
Total	33	27	6

CHERRY TREES.

Variety.	SET.	ALIVE.	DEAD.
Yellow Glass	5	4	1
Orel No. 24	5	3	2
Slanka	5	4	1
Amarilla	2	2	0
Black Tartarian	3	1	2
Griotte Precose	5	2	3
King's Morello	5	4	1
Royal Duke	2	1	1
Wragg	3	1	2
May Duke	2	0	2

Lutovka	5	4	1
Griotte du Nord	5	4	1
Bessarabian	5	3	2
Ostheim	3	0	3
Windsor	1	0	1
Tradescant	2	0	2
Montmorency	2	2	0
E. Richmond	2	2	0
Total	62	37	25

APRICOTS.

Variety.	SET.	ALIVE.	DEAD.
Gibb	3	1	2
Budd	3	2	1
Alexander	3	1	2
Total	9	4	5

PRUNES.

Variety.	SET.	ALIVE.	DEAD.
George Glass	3	2	1
Communia	8	7	1
Hungarian	15	12	3
Total	26	21	5

PLUMS.

Variety.	SET.	ALIVE.	DEAD.
Tatge	3	0	3
Spanish King	1	0	1
Wilson	1	0	1
Ogon	5	5	0
F. Garden	3	2	1
Yellow Veronesch	5	3	2
Maquoqueta	5	2	3
Wild Goose	3	3	0
Rollingstone	3	2	1
Desota	8	8	0
Hawkeye	3	1	2
Lombard	2	1	1
Coe's Golden Drop	2	1	1
Fellemburg	2	0	2
Charles Downing	2	0	2
Riga. No. 113	5	2	3
Moldovka	5	5	0
Wyant	2	2	0
Milton	3	2	1
Hammer	3	1	2

Yellow Glass	7	6	1
Wolf	3	2	1
McLaughlin	2	1	1
Weaver	3	3	0
Smith's Orleans	2	0	2
Green Gage	3	2	1
Bavay's Green Gage	2	2	0
Peter's Y. Gage	2	0	2
Total	90	56	34

RECAPITULATION.

	SET.	ALIVE.	DEAD.
Apples	214	161	53
Crab Apples	33	27	6
Pears	26	19	7
Cherries	62	37	25
Apricots	9	4	5
Prunes	26	21	5
Plums	90	56	34

Respectfully submitted,

S. M. EMERY, Horticulturist.

Report of Biologist.

To The Director.

DEAR SIR:—As Station Biologist, I would beg to submit the following brief report for the fiscal year ending, June 30, 1897:

My connection with the Experiment Station dates from September, 1896; my first work was in collecting the insects and plants of the vicinity of Bozeman.

Notes were collected of the poisoning of cattle and sheep by various plants, also on the internal chicken mite.

In the spring of 1897, these investigations were continued.

In May it was determined, by means of field work, that Larkspur is one of the important poisonous plants. The result of investigations along this line were prepared and published as bulletin No. 15.

Upon your suggestion we began a study of late spring frosts as affecting strawberries. It was noticed that a great difference is shown by different varieties of strawberries in the susceptibility to injury by frost. The varieties, therefore, in this respect manifest a physiological difference. The problem, as set before us, is to determine whether or not, there is any recognizable variation in the anatomical characters of strawberries to account for the physiological differences.

By means of sections, it was possible to make a microscopic study of the flowers and young fruit of several varieties.

Some anatomical differences were discovered, but not enough material was collected for settling the question and another opportunity must be awaited.

We spent 20 days in June in the fruit regions of the state. This strip embraced the Missoula valley, the Rattlesnake valley, Ravalli Plains, the Flathead Lake county and Holt, and the Bitter Root valley from Missoula to Como. We saw about 500,000 fruit trees on this trip, most of which were in an exceptionally clean and healthy condition; we found the following fruits under successful cultivation: apples, pears, prunes, plums, cherries, apricots, blackberries, raspberries, strawberries, currants and goosberries. A few miles from Holt, on the shore of the Flathead lake, grapes were being cultivated with considerable success. At Plains and on the Flathead lake peaches were thriving, but in the Bitter Root valley they had suffered badly from frost. We found everywhere a live interest in all questions of horticulture.

We published about 25 articles, in the chief papers of the state, on entomological and allied subjects, and delivered about 20 addresses at horticultural meetings and farmers' institutes.

Very respectfully submitted,

E. V. Wilcox, Biologist.

Report of Agriculturist.

To the Director.

Dear Sir:—Herewith I submit a report of the progress of the work in the Agricultural and Irrigation Engineering departments.

On the sixteenth of July I assumed my duties as Agriculturist and Irrigation Engineer. It was too late in the season to begin any new lines of work, and all that could be done was to carry on the experiments in grains, potatoes and roots, which had been previously started. Small grains were grown in plats and treated, as nearly as circumstances would permit, the same as field crops. Many of the grains under test have shown that they are well adapted to our soil and climate. These will be selected and planted in larger plats to determine if they will prove equally prolific when sown in larger areas. If so they will be cultivated on a more extensive scale, and seed in small quantities will be furnished farmers. New varieties selected from the best seed will be introduced and tested. A fact worthy of special mention is that during the snow storm on September eleventh, but one barley, the Chevalier, stood up straight without lodging, throughout the entire storm.

The straw of the Chevalier is much stiffer than that of other barleys and the head is held vertically so that the little snow retained upon it could not crush the stiff, strong, straw. The yield of this barley proves that it can be grown with profit in Montana.

A number of acres were sown to peas. These did well and gave an average yield of 33.6 bushels per acre. Peas have proved to be one of the best crops grown on the Station grounds. They are difficult to harvest, but their good yield and great value as a gatherer of nitrogen warrant their further cultivation. They leave the ground in better condition than any other crop, except, perhaps, clover and alfalfa.

Two crops of clover of fine quality were cut, and three excellent crops of alfalfa. These two forage plants have given better results than any other hay crop that has been tried on the Station.

In October, one hundred and two wethers were purchased for a feeding experiment to be conducted during the winter. These animals were fed various rations to determine the profit or loss of sheep-feeding in this state. At present Montana raises her sheep and cattle on the ranges, and her grains in the many fertile valleys. Both live-stock and grain are shipped to eastern markets where they are combined with profit to the eastern farmer. Is it not better tactics to feed our grain at home and thereby save the freight, the middleman's per centage, and the eastern feeders profit?

At present the Station is provided with only a few head of common stock. The sheep and cattle industry of the state occupies a prominent place, and the Station should lead in the introduction of the best pure-blooded stock, and the determination of their adaptability. The dairy industry is fast assuming a prominent place in Montana and the establishment at the Station, of a model dairy, should be started at an early date.

The work in the Irrigation Engineering department has been fully outlined for the coming year. Two self-registering water level instruments have been ordered from Paris, France, to be used in measuring the amount of water applied to various crops during the irrigation season. A record of the rain fall will also be kept, and a study of the amount of water necessary to bring crops to maturity will be inaugurated.

The Experiment Station has co-operated with the United States Geological Survey in measuring the discharge of the streams which constitute the head waters of the Missouri river. The amount of water flowing in the East Gallatin and its tributaries has also been measured at various dates, to determine the amount of return waters due to seepage, which again becomes available for irrigation. If the immense amount of water now running to waste could be utilized, it would add millions of dollars to the taxable wealth of the state.

Respectfully submitted,

FRANK BEACH,
Agriculturist and Irrigation Engineer.

Report of the Chemist.

BOZEMAN, MONT., June 30, 1897.

To the Director.

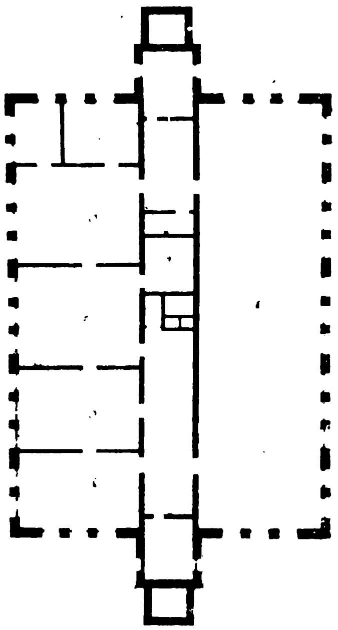
DEAR SIR:—Following is a statement of the work of this division for the past year:

Much time has been given to the analysis of Montana grown sugar beets and some very gratifying results have been obtained.

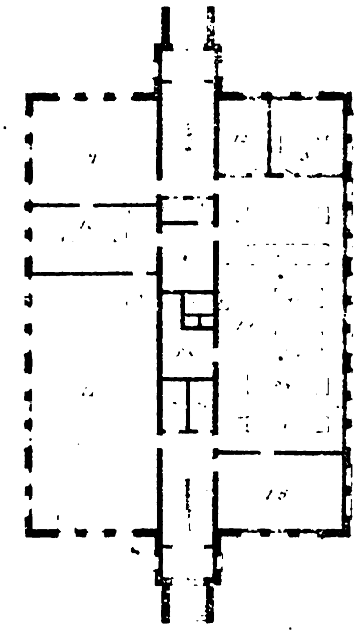
Samples grown on the Experiment Station farm and dug as early as Sept. 18, showed the presence of $19\frac{2}{10}$ per cent. of sugar. The average contents of all the beets grown upon the farm was $16\frac{26}{100}$ per cent. sugar. This is an unusually high percentage, and taken in connection with the early maturity, will be seen to present very strong evidence of the ability of Montana to produce sugar.

Samples from other sources yielded some very high results, as high as 20 per cent., with an average of $14\frac{16}{100}$. That these beets may be kept without injury to their sugar yielding contents, is indicated by the fact that samples kept until Jan. 19, yielded an average of $17\frac{2}{10}$ per cent., and this with no considerable amount of drying out. Samples grown by the Manhattan Malting Co. and tested in Germany showed a similar condition to exist. These beets were analyzed in the early

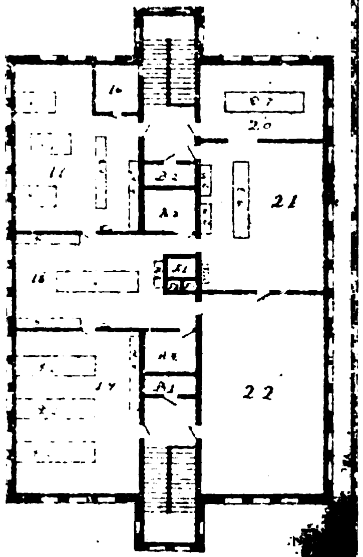
EXPERIMENT STATION LABORATORY



BASEMENT FLOOR PLAN



FIRST FLOOR PLAN



SECOND FLOOR PLAN

fall and also in the following February. They kept very well and were in as good condition for sugar making at the later period as when first dug.

A bulletin discussing the results of sugar beet experiments and analysis would have been issued had more cordial co-operation in this work been given by farmers. Despite the fact that requests were sent to farmers all over the state for their aid in this investigation, only three samples were received from points outside the Gallatin valley. The results were entirely satisfactory in all points, except the narrow distribution of the places of planting.

When it is considered that our ranchmen have had no previous experience in the growing of sugar beets, the average of $14\frac{16}{100}$ per cent. sugar for all samples is remarkable, and this combined with a purity co-efficient of 82 per cent. makes a showing which we would have been very glad to place before the public had the co-operation been more general and the conditions more varied.

The experiments on the effects of various solutions upon plants were not successful owing to uneven starting of the different plants. An absolute essential to success in this work is to have all conditions except the character of the solutions the same.

Samples of drinking water have been collected and analyzed, and the results made the basis of a popular bulletin on drinking water. In this bulletin the analytical data are discussed and precautions for securing wholesome water are given. The analysis showed far better conditions to exist than we had reason to suspect from previous superficial inspection, and that with few exceptions the water is of very good quality.

The work on the investigation of methods in co-operation with the Association of Official Agricultural Chemists has been continued with satisfactory results.

For the first time I have taken an active part in Farmers' Institute work.

This work has proved of great benefit to this division on account of the opportunity afforded for learning of the conditions and practice prevailing in other localities.

Montana is such a large state and the climatic conditions are so varied that it is absolutely essential to study the different sections carefully. Opportunity to do this and at the same time to obtain a knowledge of the views of the farmers all over the state is afforded by these meetings, which are certainly of great benefit to all taking part in them.

I have attended meetings at Livingston, Big Timber, Laurel, Billings, Red Lodge and Bozeman, and have given talks on Soil, Alkali, Food, Principles of Feeding and miscellaneous subjects.

While at Laurel the principal subject of interest was alkali soil. The Yellowstone valley above Billings, of which Laurel is nearly the geographical center, is, in places, badly affected. It is estimated that no less than 10,000 acres are incapable of yielding crops on account of excess of alkali under present conditions. On the other hand, some of the finest crops I have ever seen are grown in this same valley. The Hesper farm has yields of 1200 tons alfalfa hay from 250 acres.

So important does this subject appear that I have to give my attention largely to its study.

Already samples are being collected and analyzed. The alkali is the so-called "white alkali," sodium sulphate, or Glauber's salt, as was suggested at the meetings, there being no instance thus far of the presence of the more harmful "black alkali," the highest percentage of alkalinity in any case being but two hundredths of one per cent. calculated to sodium carbonate which is far below the amount which experience elsewhere has shown to be harmful.

The problem of successfully dealing with the alkali here is an extremely difficult one, on account of the low price of the land, for the usual remedy, underdrainage, cannot be economically applied to land costing but 3 to 12 dollars an acre. Surface washing has been suggested as a possible remedy and experiments on this line will be watched with interest.

A large amount of general analytical work has been done and where there is some value to the public in the possession of the results, no charge is made for the work, but in order to protect ourselves from a rush of work which has no more than a private value, it has been necessary to institute charges, which has been done by direction of the Executive Board.

At the same time it is our wish to have analysis of soils, forage plants, cereals and general farm products from all parts of the state, for these will possess considerable value, but in every case before sending samples it will be best for the farmer to first communicate with the Station.

The poisonous plants of the state are being collected and studied jointly with Dr. Wilcox.

Irrigation waters from different sources, and under different conditions, are being analyzed, and already some very interesting results have been obtained.

My assistant, Mr. Cobleigh, has rendered his usual efficient service.

THE NEW BUILDING.

We shall soon move into quarters adapted to our needs, after having spent four years in rooms in no way suited to chemical work. The former laboratory was small, poorly lighted, poorly ventilated and poorly heated, the new one is quite the reverse being especially designed for the purpose for which it is to be used.

The new home of the Chemical Department consists of two stories and basement, with two towers, in one of which is installed the recording metrological apparatus. It is built of pressed brick and while of unpretentious appearance is still a handsome building. The external appearance was not the prime consideration; plans meeting the various requirements being first drawn, and the exterior adjusted to these.

As economy of space was essential, large halls bisecting the building were dispensed with and the space thus saved is used for storage, dark rooms, etc.

The principal room used for the Experiment Station work is the general analytical laboratory, fifty-five feet by twenty-four. This room contains four large working desks, with water and gas conveniently distributed; two hoods are placed in the center of the room which allows free access from all sides; nearly all evaporation is done in these, so that the room is generally free from objectionable gases. A smaller hood is used solely for kjeldahl digestions. We are fortunate in having sufficient room to allow the apparatus which is most frequently used, to remain set up in place, instead of having to be taken down after each use to make room for other pieces, as was necessary in our former laboratory, this results in the saving of much time. A storage battery plant is provided, to afford, with the immersion and disc heaters, an opportunity for carrying on long time digestions, extractions and distillations, without danger of fire and need of the constant attendance of the chemist. This is designed chiefly for night work.

In order to be perfectly safe from the possible errors introduced by the presence of ammonia in the atmosphere, the ammonia and nitrogen determinations are made in a room separated from the general laboratory by glass partitions and independently ventilated. All titrations are made in this room.

Adjoining this room is a smaller room used as a balance room, it receives only north light.

Two large closets occupying the central portion of the floor give room, one for storage of chemicals and glassware, and the other for a dark room for polariscopic and photographic work.

Across the hall from the general laboratory is the office and department reference library. The department library contains an excellent foundation of reference books in analytical chemistry particularly, and is a great aid in research work. In the basement is the gas machine of five hundred lights capacity, which furnishes gas for light and laboratory fuel purposes for the whole institution.

A two-horse power gasoline engine furnishes power for running the pulping and grinding machinery and the milk testers.

In the North Tower and upon the roof is installed a set of self-recording meteorological apparatus.

A quadruple register by Frieze, on which is recorded wind velocity, wind direction at the end of each minute, rainfall by the tipping bucket, rain gauge, and sunshine. All these instruments are connected electrically to the register. A Richard's recording barograph records the variations of pressure and is checked daily by readings taken from a very fine mercurial barometer made by Green. A recording thermometer occupies an instrument shelter placed upon the roof.

The half tone cuts give a general view of the building, an interior view of part of the general laboratory and floor plans of the three floors.

On the same floor with the Experiment Station laboratory is the Chemical and Physical lecture room especially designed for demonstration lectures. A large desk provided with water, gas and a hood stretches across one end of the room, a black-board is placed behind the desk and electric wires giving a considerable range in voltage and amperage are conveniently placed for experiment purposes. A very fine set of physical demonstration apparatus is placed in the adjoining preparation room. In chemical apparatus we are equally well supplied.

A scientific lantern with a complete set of accessory apparatus is placed at one of the South windows so that during sunshine, solar light may be used for projection purposes, when this source of light fails we have either the electric arc lamp, the oxy-hydrogen jet or the acetylene burner available. Arrangements have been made for quickly darkening the room whenever it is desired to use the lantern. The regular university chair with tablet arm for note books is used in this room as well as in all other class rooms. A small room on the other side of the hall is used for small classes. The second story is used for students' laboratory work in chemistry, physics and mineralogy. The desks and hoods are similar to those shown in the illustration of the Experiment Station laboratory and are fully equipped with apparatus and re-agents. The special feature of this floor is the arrangement of rooms whereby the instructor's room is easy of access from all of the student laboratories. This makes oversight of all the rooms possible and renders consultation with the instructor convenient without passing through other rooms.

The basement supplies a large well-lighted room for a museum of applied chemistry, geology and mineralogy, and rooms for assaying, for the preparation of samples for analytical work, and for the storage of duplicate specimens, kept for exchange with other institutions.

The assay laboratory consists of three rooms, the balance room, the general preparation room where each student has his desk with chemicals, apparatus and pulp scales, and the furnace room. The furnace room, besides having the gasoline engine and grinding machinery mentioned elsewhere, has four large size Hoskin's crucible furnaces, one No. 5 Hoskin's crucible furnace, three No. 3 Hoskin's muffle furnace, one No. 4 Hoskin's muffle furnace; these all use gasolene for fuel. The gasolene is stored under ground a considerable distance from the laboratory in a 1,000 gallon tank, and when required is forced into the furnaces by an air pump, this pump is close to the furnaces. When no longer needed the pressure is removed and the gasolene flows back into the tank. The building is heated by means of four large furnaces located in the sub-basement.

By means of a large fan placed in the shop, air may be forced through underground ducts into the building.

A large flue situated in the center of the building is connected with each room and the constant draught maintained in it affords an excellent means of ventilation. A boiler in the sub-basement, not only supplies abundance of distilled water but also supplies steam for radiators placed in the ventilating flue. It will thus be seen that no matter what the atmospheric conditions are it is possible to keep the atmosphere always fresh and pure either by natural or forced draught. The floor plans accompanying this description, together with the legend, will render it easy to understand the arrangement and uses of the different rooms.

With the new conditions prevailing it will be possible for us to greatly increase the efficiency of the Chemical Division.

Respectfully submitted,

F. W. TRAPHAGEN, Chemist,

Thanks are due to Fred F. Willson for the drawings of the chemical building.

Basement.

1. Assay Balance Room.
2. Janitor's Room.
3. Assay Laboratory.
4. Furnace Room.
5. Sampling Room.
6. Exchange Room.
7. Museum.
D. 1. Assay Desks.
H. 4. Hood.
I. Grinding Plate.
J. Fraser & Chalmer's Grinding Machine.
L. J. B. Low Ore Sampler.
M. Blake Crusher.
N. 2 H. P. Gasolene Engines.
O. Bullion Rolls.
P. Muffle Furnaces.
Q. Crucible Furnaces.
R. Milk Tester.

S. 1. Grain Grinder.
G. Work Bench.
S. Shelves.
D.8. Desk.
T. Exchange Table.
8. Blower Room.
E. Blower for Gas Machine.
W. Weight for Blower.
S. C. Storage Closet.
A. 1. Storage Room for Assay Apparatus and Chemicals.
F. 1, 2 and 3. Flues.

Second Floor.

16. Balance Room.
17. Quantitative Laboratory.
18. Instructor's Laboratory.
19. Qualitative Laboratory.
20. Laboratory for Blowpipe Analysis and Determinative Mineralogy.
21. Laboratory for Sophomore Physics.
22. Laboratory for Preparatory Physics.
D. 1. Quantitative Desks.
D. 5. Desk for Distillation, etc.
H. 4. Hoods for Students' Use.
D. 3. Wall Desks for Instructors.
D. 4. General Work Desk.
H. 5. Instructor's Hood.
D. 2. Desks for Qualitative Analysis.
D. 6. General Work Desk for Physics.
A. C. Apparatus Cases.
D. 7. Blowpipe Desk.
B. 1. Ladies' Cloak Room.
B. 2. Cloak Room.
A. 3. Storage Closet for Quantitative Apparatus.
A. 4. Storage Closet for Qualitative Apparatus.
F. 1. Flue for Ventilation of Rooms.
F. 2. Flue for Ventilation of Hoods.
F. 3. Flue for Furnaces and Boiler.

Legend.

First Floor.

9. Office and Department Library.
10. Preparation Room.
11. Chemical Lecture Room.
12. Balance Room for Experiment Station Work.
13. Nitrogen and Titration Room.
14. General Laboratory of Experiment Station.

15.	Small Lecture Room.
B. S.	Book Shelves.
A. C.	Physical Apparatus Cases.
D. 9.	Preparation Desk.
H. 6.	Hood for Preparation of Chemical Experiments.
I. D.	Desk for Demonstrations in Chemistry.
P. A.	Projection Apparatus.
H. 5.	Lecture Desk Hood.
T. D.	Titration Desk.
D. D.	Desk for Distillation.
K. D.	Desk for Kjeldahl Distillation.
F. D.	Filtration Desks.
P. D.	Precipitation Desks.
S. H.	Slop Hoppers.
H. 1.	Hood for Digestion and Boiling.
H. 2.	Hood Containing Dangler Battery and Water Baths.
D. S.	Draining Shelf.
H. 3.	Hood for Kjeldahl Digestions.
A. 2.	Storage Closet.
F. 1.	Flue for Ventilation of Rooms.
F. 2.	Flue for Ventilation of Hoods.
F. 3.	Flue for Furnaces and Boiler.
P. A.	Dark Room for Photographic and Polariscopic Work.
B. 1.	Ladies' Cloak Room.
B. 2.	Gentlemen's Cloak Room.

630.679
M9eb

CLASS.................UNIV. OF MICH.
BOOK.......................JAN 18 1909
REC'D ...MAY....10 1899

BULLETIN NO. 17.

Montana Agricultural Experiment Station

......OF......

THE MONTANA COLLEGE OF AGRICULTURE.

The Grain Aphis.

An Army Cut-Worm.

BOZEMAN, MONTANA, APRIL, 1898.

ROCKY MOUNTAIN HUSBANDMAN,
White Sulphur Springs,
MONTANA.

46

Montana Agricultural
EXPERIMENT STATION.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman.
Peter Koch, Secretary and Treasurer	Bozeman.
George Kinkel, Jr., Vice-President	Manhattan
Walter Cooper	Bozeman
Nelson Story	Bozeman

EXPERIMENT STATION STAFF.

S. M. Emery,	Director and Horticulturist.
F. W. Traphagen, Ph. D., F. C. S	Chemist.
E. V. Wilcox, Ph. D	Biologist.
Robt. S. Shaw, B. S. A.	Assistant Agriculturist.

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

Montana Experiment Station,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any itizen of Montana who sends his name and address to the Station for t purpose.

MONTANA EXPERIMENT STATION.

Bulletin No. 17. **April, 1898.**

The Grain Aphis.

Siphonophora Aoenae (Fabr.)

BY DR. E. V. WILCOX.

The grain aphis has long occupied a prominent place among the enemies of the cereal crops. It attacks wheat, oats, barley and rye, and sometimes grasses and a few other plants. It is to be found on grain crops every year, but, usually, not in such abundance as to cause great damage. There are, however, occasional years of serious invasions by this insect.

This periodical recurrence of large numbers of the pest is a phenomenon which has been observed in the army worm, Rocky Mountain locust and many other injurious insects. To many people it seems little less than miraculous that an insect, which for several years has not been noticed, should suddenly appear in such numbers as to threaten the very existence of some crops. We cannot wonder at a widespread popular belief in spontaneous generation as an explanation of the matter.

The causes of alternating periods of relative scarcity and abundance of the grain aphis are not easily stated. In fact they are not definitely known. It will readily be seen that we cannot explain the great prevalence of a particular insect at a particular time without knowing all the conditions which are favorable to the development and multiplication of that insect. We know that the offspring of almost any species of insect would, if they should escape their enemies and should all come to maturity, very soon run into numbers of startling size.

Now the enemies of the grain aphis are numerous and energetic, but they are not always equally numerous. Furthermore the climatic conditions are sometimes more favorable to the grain aphis than at other times. If, therefore, we suppose a year in which the climatic and other conditions are most favorable to the grain aphis, and in which its enemies are unusually scarce, the majority of the offspring of the aphis will come to maturity and grains will be greatly damaged.

The grain aphis like many more of our injurious insects is of European origin. Its distribution, however, has become worldwide and it is found in nearly every grain-raising section on the globe.

This insect is too well known to require any detailed description. A very brief account of its appearance should be sufficient to enable anyone to recognize the grain aphis and to distinguish it from the other insect enemies of the grain crops.

The grain aphis belongs to the aphididae or family of plant-lice. We have several other common representatives of this family in the state, such as the green aphis of the apple and the cabbage louse.

The length of the mature grain aphis is somewhat less than one tenth of an inch. The color of the insect varies exceedingly. It may be green, yellow, red, or brown. During the spring and early summer while the aphis is feeding upon the stem and leaves of grain, its color is green. Later in the season, when the heads of the grain begin to change color the aphis undergoes corresponding changes of color and we find red, brown and yellow individuals. Each aphis bears a delicate pair of feelers, a pointed beak, and three pairs of legs. Wings are either present or wanting. On the upper surface of the hinder portion of the abdomen are two short projecting tubes. These tubes correspond to the honey tubes of other plant lice. It is doubtful, however, whether the grain aphis secretes any honey dew. At any rate we have never seen them attended by ants.

As mentioned above, the grain aphis occurs during some years in incredible numbers. During the last season a rather serious outbreak occurred in many parts of the state. There were reports made from Gallatin, Silver Bow, Ravalli, Missoula, Granite, Park and Yellowstone counties. Wheat and oats were more infested than other grains. In many cases the grain aphis was present in such great numbers that considerable trouble was experienced in reaping the grain, the canvas of the binder would become smeared and greased with the crushed bodies of the aphis. It was necessary to stop frequently and clean the canvas and other parts of the machinery.

The extra work in reaping the grain is, however, not the chief damage done by the grain aphis. As the grain grows the insect moves upward and at the earliest possible moment locates itself on the heads of the grain among the kernels. Here it remains until the grain is ripe. Its method of attack is not by biting away any part of the grain but by sucking out the nutritive juices. As to the actual amount of injury which is caused by these insects, opinions vary to some extent, but the general consensus of opinion is that the damage is considerable. Some authorities say that the damage amounts to from 25 per cent. to 50 per cent. of the crops in cases where the grain aphis is very abundant. A few entomologists, on the other hand, have considered the attacks of this aphis as of no great significance. We firmly believe that the presence of any large number of these insects upon the heads of grain must cause a serious drain upon the food supply which otherwise would have been stored up in the kernels.

Director Emery has suggested that we try some experiments to determine the exact amount of injury by the grain aphis. Such experiments will be performed this season if the aphis appears in large numbers. We do not know of any careful experiments with this object in view. Naturally the loss is not in the number of the kernels but in their size and weight. We noticed during last season a considerable shrinking in the kernels of badly infested grain.

The life history of the grain aphis is not known in a satisfactory manner. The greatest uncertainty has prevailed as to its whereabouts in winter and as to its method of passing the winter. Some have maintained that in late summer the aphis leaves the wheat and oats for some unknown host plant and passes the winter in an unknown state, probably in the egg, to reappear in the spring upon the young grain. It has been suggested that the winged females migrate to winter wheat in the fall and pass through the winter in a frozen state on the leaves of the wheat and thaw out in the spring to begin their activities anew.

Webster tried by experiment to determine the winter history of this insect and failed. He says:—"I was wholly unable to keep them on young wheat plants growing in the insectary, after the kernels began to harden in the wheat heads in the fields outside. They simply will not stay on wheat during midsummer."

Dr. Fitch in 1862 says:—"I have watched the grain aphis this year round so closely that I am perfectly assured that no eggs were laid and no eggs were produced. When and under what circumstances males occur, if they ever do occur, is yet remaining to be discovered." Thomas, in the winter of 1875, found what he believed to be the grain aphis on the roots of winter wheat. He claims to have found them "busy at work under the snow."

Gorman maintains that the grain aphis goes down on the roots of winter wheat in the fall. Hopkins and Rumsey say:—"The winged females deposit eggs on the young wheat in the fall; the eggs hatching in the spring into female lice, which soon give birth to living young."

In our own experience we have not been able to find any males or eggs. On the grounds of the Experiment Station we had opportunity to study the habits of the grain aphis. On wheat the aphis was present in great numbers. They remained in full force upon the wheat heads until the wheat was cut. As soon, however, as the wheat began to dry up, they crawled down from the shocks and attacked the clover which was standing in the wheat stubble. At this time there were both winged and wingless females. The winged females, as a rule, did not fly, but crawled down upon the clover with the wingless ones. As a necessary result of this habit of the grain lice, within about twenty-four hours after the wheat was cut, the lice were to be found very abundantly in a circle around each shock. They attacked not only clover but also the partly green leaves at the base of the wheat stubble, as well as jointweed (Polygonum), pigweed (Amarantus), and any green thing. As cold weather came on they crawled into the sheaths of the clover-leaves and later went down upon the clover roots. In November we found them in considerable numbers on the clover roots.

Along the edge of another field a single row of winter wheat had been sown in the spring. This did not come to head, and, at the time when the other wheat was cut, was fresh and green. The grain aphis crawled upon this row of green wheat in great numbers. They remained upon it until late in the fall, when part of them hid themselves in the leaf-sheaths at the base of the stems, while others crawled down upon the roots. Two of their enemies, the larvae of a Syrphus fly and adult Ladybirds followed them into their retreats and passed the winter with them.

As soon as the frost was out of the ground this spring, we made a search for the grain aphis. We could find only a very few living aphides. But several larvae of a Syrphus fly were found with the skins of grain lice still hanging about their heads, and an incredible number of Lady birds were present. Both the Syrphus fly larvae and the Lady bugs were crawling about on the leaves seeking out the hiding places of the grain aphis.

We spent a few hours in the early spring in a field of winter wheat which had been seeded upon stubble ground after harvesting a crop of spring wheat. We succeeded in finding only five or six grain lice but fully as many thousands of Lady bugs, numerous larvae of a Syrphus fly as well as the skins and remains of grain lice.

These observations do not exclude the possibility of the existence of males and of egg laying females. Other plant lice, whose life histories are well understood, bring forth a generation of males and females in the fall. After pairing and depositing eggs these individuals die and the species passes the winter in the egg state. At least a number of the grain aphis, however, winter over as viviparous females, and these begin to bring forth living young in the early spring.

As far as our experience in the Gallatin valley goes the life history of the grain aphis may be briefly outlined as follows:—In the early spring the viviparous females which have wintered over on the roots of winter wheat come up on the leaves. Here and later upon the wheat heads an indefinite number of generations are passed until the wheat is cut. Then the aphis emigrates to oats, clover, various grasses and volunteer oats and wheat and finally to winter wheat upon which it preferably passes the winter.

REMEDIES.

We shall speak first of the natural forces which hold the grain aphis in check. A cold rainy spring is recognized as being unfavorable to the rapid multiplication of the aphis. But besides unfavorable climatic conditions, this insect has several enemies with which it must contend. Not only are the grain lice killed by internal parasites but various predaceous insects feed upon them. On the grounds of the Experiment Station we observed a number of insects which devoured the grain lice. These were, in the order of their importance, Lady bugs, Syrphus fly maggots, and Aphis-lions (chrysopus). Of the Lady bugs the following species, as identified by the Division of Entomology U. S. D. A., were engaged in the destruction of the aphis:—

Hippodamia 13-punctata.
Hippodamia parentheris.
Hippodamia 5-signata.
Coccinella 3-fasciata.
Coccinella 9-notata.
Coccinella transversalis.

The lady bugs with their hemispherical bodies and red and black colors are everywhere recognized as among the most effective of our insect friends. The Syrphus fly larvae are pale greenish maggots of a flattened spindle shape. They feed upon all sorts of plant-lice and deserve recognition for their good work.

During last season the lady bugs were present in numbers far in excess of any previous observation we have ever made. Four and five adults were frequently noticed on a single head of wheat. The larvae of the lady-bugs are also active destroyers of plant-lice. They crawled under boards and stones to pupate and were often found in such situations in masses. Fifty larvae of a lady-bug were found on the under side of a sheep skull. The larvae were preparing to undergo their metamorphosis. In all sorts of situations the lady-bugs in both adult and larval condition were observed in quite unusual numbers. They passed the winter along with the grain aphis and have appeared in abundance this spring. They seem to be particularly numerous on winter wheat.

It is somewhat unsafe to make predictions about such insects as the grain aphis, but we believe that the aphis will not multiply to such numbers this season as during the last season. The spring has been less favorable to their development and their enemies are present and on the lookout in great numbers.

We shall now consider the question of artificial remedies. Fletcher in his report for 1896, says: "No special treatment can be recommended for the grain plant louse, nor, as a rule, is any remedy necessary, for the natural parasites suffice to keep it in check." Numerous remedies, however, have been suggested by various writers on the subject.

Wherever the farmer has an efficient spraying apparatus, such as would be required for work in a large orchard, experiments have shown that kerosene emulsion and tobacco water are good remedies. If this method is adopted, the spraying should be done in early summer or before the grain has headed. After the aphides have once gotten among the chaff of the grain heads it is difficult to reach them all with an insecticide. Gorman recommends also "freshly slacked lime with a little crude carbolic acid added, to be sown broadcast on infested wheat or oats." Dr. Fitch suggested the use of chloride of lime dusted over the plants.

Dr. Lintner, in speaking of remedies for the grain aphis, says:—"We are compelled to admit that no method has been discovered by which its formidable attack upon a grain crop can be arrested."

On this same subject Cook remarks:—"Not only are the artificial remedies impracticable, because of necessary lack of thoroughness, but they are also undesirable; because of the large damage that is done to the grain in their use. We cannot drive through a grain field without causing serious destruction to the crop."

Dr. Reuter, of Finland, states that artificial remedies in that country have failed to be satisfactory. In our opinion the best suggestions in the way of remedies have been made by Washburn. This author advises to burn the stubble immediately after harvest, to cultivate the soil, removing all grass and weeds, and not to raise a grass or grain crop on the same land the next year.

Within twenty-four hours after the wheat had been cut we found myriads of the aphis on the stubble, clover and weeds. There the lice remained for about ten days. Evidently great numbers of them would have been destroyed by burning the stubble, and we would recommend it wherever practicable.

As already mentioned, after the wheat was cut, the lice fed upon clover, several grasses and a few weeds such as Polygonum and Amarantus, as well as upon volunteer wheat and oats. It is apparent, therefore, that if the ground were thoroughly cultivated soon after harvest and all grass, volunteer oats and wheat, and weeds in and around the field were destroyed, the majority of the lice which were upon such plants would be killed.

Moreover, if no grass or grain crop were raised on the field during the year succeeding a bad infestation by the grain aphis, no suitable food plant would be found by the aphides which succeeded in passing the winter on the ground. It would seem especially unadvisable to sow winter wheat directly into a stubble field without cultivation, or upon ground where volunteer oats or wheat had been growing. In short we believe that the habits of the grain aphis give us one more argument in favor of clean cultivation and a proper rotation of crops.

An Army Cut-worm.

BY DR. E. V. WILCOX.

During the first part of May of the current year we received specimens of a supposed army worm from the Missoula valley. Specimens and letters concerning the same were received from C. H. Edwards and H. C. B. Colvill. We visited Missoula a few days afterward and found a serious outbreak, not of the true army worm of the eastern and southern states, but of another species of cut worm with the army worm habit. This cut worm, as identified by the kindness of Dr. L. O. Howard, is Chorizagrotis agrestis.

So far as could be elicited by inquiry from the people in the vicinity of the outbreak, the insect had not been noticed before in this locality. No one remembered having seen it in the caterpillar stage. It was reported that a large number of moths presumably of a cut worm had been found in the globes of the electric street lights, during late summer of the preceding year. Otherwise the cut worms seemed to be looked upon as an entirely unheralded and unexpected visitation.

The distribution of this insect in the state is, so far as ascertained, rather limited. We have neither seen specimens nor heard complaints of it from any other part of the state than the Missoula and Bitter Root valley. It occurred abundantly in Missoula on both sides of the river. In south Missoula the cut worms quite largely destroyed the pleasure of walking, for they crawled about on the streets and sidewalks in great numbers. The caterpillars were tramped under foot at almost every step and were crushed by the wheels of wagons and bicycles. Inside of the city limits the caterpillars were eating or on the march day and night.

In the Bitter Root valley they were found, so far as we could discover, only on the east side of the river. A careful search from Missoula to Hamilton revealed none on the west side. Along the east side of the river they were observed in about a dozen localities, but no well organized army was present except in one of these places.

In all localities the cut worm was, or had been during the season, almost equally abundant on the foot hills and in the bottom lands. It was impossible to say with absolute certainty in any case whether the army originated in irrigated or unirrigated lands. Nor could it be determined whether the insect marched from the foot hills into the valley or from the valley into the foot hills. The indications were, however, strongly in favor of the former supposition. No one in the infested localities remembered to have seen the insect in any considerable numbers before, and we were everywhere confronted with the question where it had come from.

The curiosity of the general public is always much aroused by the periodical abundance of certain insects. The recurrence of plagues of insects has been noticed and remarked upon in the case of several well known species. The occurrence of the broods of the Periodical Cicada at long regular intervals is readily explainable as due to the long life of the Cicada in an immature stage. In the case of insects, however, which occur annually the problem is quite different. Reference has already been had to this question in discussing the grain aphis.

From the evidence at hand we believe that our army cut worms had been living on the foot hills in unpretentious but steadily increasing numbers. Under such circumstances abundance of food would be found where the eggs were hatched and the caterpillars would not be forced to migrate in quest of other food-plants. When, however, for any reason, as happened during this year, their numbers should be greatly increased, the food in the immediate vicinity of the hatching of the caterpillars would soon be exhausted and they would be compelled to move to new feeding grounds. Since, moreover, they possess by no means fastidious tastes they attack almost any cultivated crop with which their line of march brings them in contact.

Several insects when occurring in unusual numbers have assumed the army habit and have thus acquired for themselves the appellation "army worm." On the other hand the true army worm when much reduced in numbers does not march in armies and behaves very much like other cut worms. It has frequently been asked why caterpillars when travelling in armies should all have a common direction of march. To this question it would seem to be sufficient to reply that it is the only economic way for them to march, the only method, in fact, by which they do not interfere with one another and hinder the passage of one another. In no other way could the worms all be headed toward fresh feeding grounds.

We have already referred to the fact that the caterpillars under discussion are not at all particular as to what they eat. We found them actually feeding upon a large variety of plants. The list of food-plants observed includes the following species:—Clover, lupine, alfalfa, sanfoin, cabbage, horse radish, radish, mustard, turnips, shepherd's purse, timothy, bluejoint, red-top, wheat, oats, rye, barley, thistle, Balsamorrhiza, cactus, beets, strawberry, cherry, apple, peach, apricot, prune, plum, raspberry, currant, gooseberry, blackberry, corn, peas, celery, tomato, potato, onion, avens, larkspur, rhubarb, dandelion, and numerous native grasses. Their dietary is not even confined to green plants. In a devastated grain field we found them eagerly devouring dry grain stubble and the dry roots of various weeds. When all other available food is exhausted they turn upon one another and become cannibals. In post-holes we observed masses of them which had been preying upon one another for two weeks.

The feeding habits of this cut-worm are like those of the true army worm. As long as the food is abundant they feed preferably at night and remain concealed during the day in the ground or under sticks and stones. During cloudy days they usually come out to eat. On bright days, however, they are not to be seen until about five or six o'clock in the evening when they emerge from their hiding places. But when food is scarce they are to be seen eating at midday of sunshiny days.

Like the army worm this insect has the habit of eating everything above ground, or rather all tender parts of the plants which are chosen as food. Some other species of cut-worms have the well known habit of merely cutting off their food plants close to the surface of the ground.

The army of cut-worms which appeared on the north side of the Missoula river was the one which did most damage and was the one which we studied most carefully. The worms appeared about the first of April and by the first week in May when we visited the locality they had marched three miles in a northwest direction, doing considerable damage all along the line of march.

A portion of the territory which was traversed .during this journey was covered with native grasses which did not seem much to the liking of the caterpillars. One flank of the army passed through a cemetery and despoiled the graves of their green covering in a night. The destructive power of the army, however, was not suspected until it arrived at young fields of grain. Here an aggressive campaign was organized and results were produced which could not fail to bring consternation to the farmer. The rate of march varies exceedingly and depends, in the absence of physical barriers, almost entirely on the number of the caterpillars and upon the quantity and quality of food to be found.

Mr. John Richlie was the chief sufferer. In an incredibly short space of time the cut-worms ate up forty acres of young oats belonging to this one farmer. The oats stood about four inches high. The worms ate every stem of grain and left the ground perfectly bare behind them. They ate not only all that was above ground but ate the grain down to the depth of one inch below the surface of the soil. The ground looked as if it had been summer fallowed. Not a sign of the crop was to be seen and during the middle of the day no cut-worms were in sight. By removing the first inch of soil, however, we were able to find from fifteen to forty worms to the square foot. At about sunset the caterpillars emerged from the ground, and then constituted a formidable and destructive army.

The farmers, as might be supposed, were anxious to know how to defend themselves against the attacks of these enemies. Rolling the fields had already been tried, but the rolling had been done in the day time and as the worms were at the time hidden beneath the soil the pressure was found insufficient to crush them and they escaped without injury. In order to be effective such a remedy must be applied at night when the worms are on the surface. At first we advocated this to some extent but other less expensive and more effective remedies were soon devised.

One of these was the use of running water in ditches. This method gave good results, and when properly and carefully executed is perhaps the simplest and most efficient means of combatting insects with habits such as those of the cut-worm under discussion.

A ditch should be plowed through the field somewhat in front of the advancing army. The ditch should be so laid out that the fall is considerable and as regular as possible. It is advisable to make the banks of the ditch as steep and smooth as may be. There should be no sharp curves or other obstruction which might produce an eddy or dead water. The width ought to be not less than a foot at the bottom. The water should be about six inches deep and the ditch ought not to be level full.

In our experience these precautions were found necessary in order to make the remedy operate as desired. The first ditch which was plowed did not have a perfectly regular fall. In consequence of this there were places in the ditch where the water moved very slowly or came almost to a standstill. At such points the worms, which had marched into the water and were being carried along, sank to the bottom and filled up the ditch until the sides gave way and bushels of worms floated out into the hitherto uninfested portion of the field.

We found it indeed unsafe to leave such a ditch unpatroled for more than ten hours. The ditch was sure to become obstructed by the mass of worms lying on the bottom. Where the worms are as abundant as they were in this field it is necessary to keep the ditch under constant observation. If the cut-worms accumulate in too great quantities they must be shoveled out and destroyed.

By way of giving a reason for such advice we may perhaps best relate a part of our experience with the use of ditches. When the army of cut-worms came to the ditch they walked deliberately into the water and were carried away with the current. The vast majority of them soon sank to the bottom of the ditch at points where the current was less rapid. Now at first thought it would seem that here was a simple solution for the whole problem. Not so. The ditch soon became dammed up at various points by the bodies of the worms, the side wall gave way and bushels of nearly stupified worms floated out into the grain. Here they soon reached dry ground and it immediately became necessary to run another ditch inside of the first one through the field in order to stop the invasion. The same accident happened time and time again and new ditches were required. In this way the enemy kept constantly advancing and the owner of the grain was forced to retreat behind other ditches.

According to our experience it is necessary not only to have smooth ditches with a regular fall, but also to shovel out the worms occasionally where there is danger of their damming the stream. Nor is this all. The worms should be killed. By actual experiments we determined that a large proportion of the worms remained alive when submerged in water for forty-eight hours and some few kept alive for three days. The apparently dead worms from the bottom of the ditch began to move within a few minutes after they were exposed to the air.

The cut-worms hesitate at nothing that lies in their pathway. They accordingly all crawl into the ditch. About 95 per cent. of the worms which get into the water sink to the bottom. The remaining few float upon the surface and succeed in crawling out on one side or the other. We observed worms crawl into a ditch and then escape on the opposite side after floating for over half a mile. From such observations it is evident that the worms might cross water courses of considerable width. A large army, however, can be stopped and almost entirely destroyed by a stream of water eighteen inches wide. A ditch is thus seen to be a very effective remedy although it does not offer an absolute barrier to every worm. At least 90 per cent. of the worms may be killed by a proper application of the method.

The immense number of the cut-worms was all that prevented this remedy from being entirely successful at the beginning of the attack. We may say without exaggeration that several wagon loads of worms were drowned. At one place for a distance of about two hundred and fifty feet, where the ditch averaged two feet in width, the cut-worms lay on the bottom in a solid mass of the thickness of from six inches to one foot. The many miles of irrigation ditches in the vicinity showed cut-worms under water all along their length. It is therefore impossible to estimate the enormous quantities of them which were destroyed in this way.

Where the worms had escaped by the breaking out of the ditch in the manner described above we recommended to Mr. Richlie that he use Paris green in making a poisoned bait. He accordingly cut some clover, dipped it in a strong solution of Paris green (½ pound to 25 gallons of water), and spread in a line in front of the advancing column of worms. We did not have time to await the results of this experiment. Mr. Richlie, however, was more pleased with this than with any other remedy. He reported that it was entirely successful. The whole advancing line of worms was destroyed. As many as sixty dead worms to the square foot were found under the poisoned bait.

At another place in the Missoula valley we found a remedy in use which was not very successful and for still other reasons is not to be recommended. This method consisted in simply irrigating the infested fields. Very little can be said in favor of this procedure. Nearly all of the worms endure with impunity a thorough irrigation of two days duration. But, more than this, it is well known that until the grain shades the ground it is somewhat dangerous to irrigate heavily, excepting perhaps in the case of loose gravelly soils.

While we believe that the remedies which we used are the most effective against the cut-worms, it may be well briefly to refer to certain other methods which have been applied to the army worm. The burning over of grass lands known to be infested with the worms would probably be effective if done in early spring or late fall.

Where water is not to be had conveniently ditches may be plowed with a perpendicular wall toward the part of the field to be protected. Then as the ditches are filled with the worms, they may be cleaned by killing the worms with kerosene or otherwise and shoveling them out. Or deep holes may be dug at intervals in the bottom of the ditches and the worms may then be crushed as they fall into these holes.

Another remedy, which was suggested by Dr. Riley, consists in setting up a line of boards on edge and then smearing ths boards along the upper edge with kerosene or coal tar. If the worms should threaten to pile up so as to be able to crawl over, they may be dosed with kerosene and shoveled away from the boards.

A narrow strip of the crop in advance of the army may be sprayed with Paris green or London purple, or the worms may be destroyed directly by spraying a strong kerosene emulsion upon them.

Sirrine recommends as a poisoned bait the use of equal parts of bran and midlings in the proportion of twenty pounds of the mixture to one pound of Paris green. It is most effective if used dry.

Besides field crops the cut-worms attacked gardens. We visited several gardens where beets, onions, radishes and strawberries had disappeared in a single night as if by magic. Here the poisoned bait could be used to advantage, or the crops could be sprayed with Paris green.

On the east side of the Bitter Root valley, near Florence, the cut-worms attacked an orthard of forty acres of young trees. The ground had been thoroughly cultivated and there was not a green thing in the field except the buds of the trees. These the worms attacked with avidity, boring into the young stems to the depth of one-half inch. They took the lower buds, and not all the buds on any one tree were destroyed. The damage was, therefore, confined to a sort of irregular pruning. Food was so scarce in this field that the worms were compelled to feed day and night. In this case a trap crop of grain heavily sprayed with Paris green would have protected the orchard. The attack, however, was unexpected and the damage was done before a suitable remedy could be devised. Should another outbreak occur we would recommend the use of irrigation ditches to repel the invaders.

The worm under discussion is of the ordinary cut-worm type and varies exceedingly in general coloration. The caterpillar attains the length of two inches when full grown. It is nearly smooth, having only a few short hairs scattered along its body. The ground color of the worm varies from light green to a dark brown. There are alternating longitudinal light and dark bands along the side. This species is probably double-brooded in Montana and the second brood may be expected in late summer. The insect winters over mostly in the caterpillar stage and the worms begin operations early in the spring. In the adult stage it is a brown moth with gray markings having a wing expanse of about one and one quarter inch.

Outside of cultivated fields the cut-worms were also very much in evidence. Aside from the ordinary garden and field crops their favorite food plants seemed to be the so-called "wild sunflower" (Balsamorrhiza sagittata) and avens (Geum triflorum). In May the wild sunflower covers the hills with its luxuriant leaves and large yellow flowers. As the cut-worm army marched along the hillsides they left no trace of the wild sunflower behind, and from a distance of several miles one could see the sharp line of demarcation between the devastated and untouched areas and could thus easily determine the direction of march and whereabouts of the various armies of worms.

The cut-worms seemed to manifest an especial fondness for the prickly pear cactus. The caterpillars ate their way into the thick stems of the cactus and devoured the pulpy mass, leaving a mere shell. This proclivity, however, on the part of the worms caused the death of many of them. We found hundreds of them which had died after becoming inextricably entangled in the spines of the cactus.

Our cut-worm has numerous natural enemies. We observed species of ground beetles (Harpalus and Calosoma) as well as the whirligig beetles (Gyrinus and Dyneutes) attacking the caterpillars in the ditches. Many a ground beetle was to be seen making a meal out of a caterpillar as they both floated down the stream. Unfortunately numerous beetles were drowned while performing this difficult feat, but they were in search of the caterpillars in and out of the ditches and doubtless had considerable effect in reducing their numbers. The whirligig beetles made a vigorous attack upon the worms when they fell into the ditches.

But besides predaceous and parasitic insect enemies the birds did their share of the destruction of the cut-worms. The black bird, robin, crow and meadow lark were seen to eat the caterpillars. Domestic poultry also had learned the advantages of a cut-worm diet.

We believe that their numerous enemies have greatly reduced the numbers of the cut-worms and therefore do not expect that the attack next year will be nearly so serious as that of the present season. It would not be wise however to neglect all precautions, and we would urge that should the cut-worms appear next spring in alarming numbers, the most convenient one of the above mentioned remedies be applied immediately after the appearance of the caterpillars.

The figures accompanying this account are from photographs by Le Roe Emery who rendered other valuable assistance in investigating the outbreak of cut-worms.

Fig. 1. shows the worms lying in the bottom of a ditch. They were lying lengthwise of the stream. Since the worms were about three inches beneath the surface of the water considerable difficulty was experienced in photographing them.

Fig. 2. shows a view of a portion of a heap of worms which had been shoveled out of a ditch.

* * *

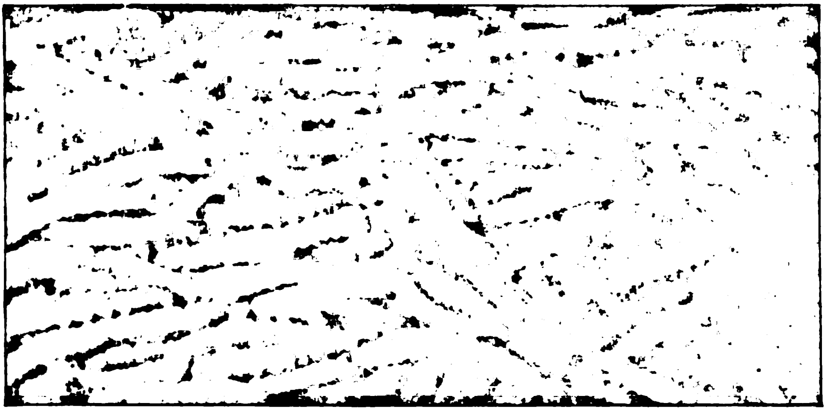


Fig. 1. Showing worms in irrigation ditch under water.

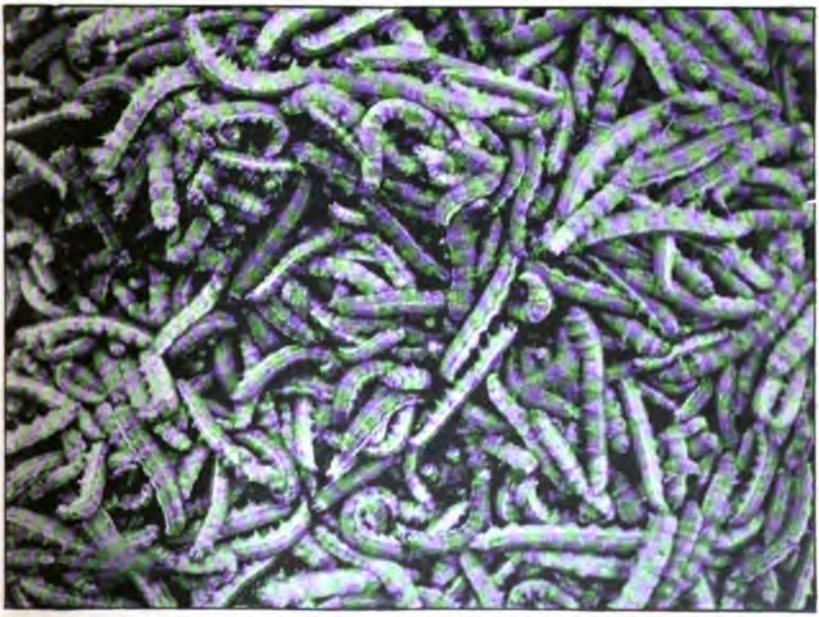


Fig. 2. A heap of dead worms shoveled out of ditch.

630.679
M9eb

Dup

UNIV. OF MICH.
JAN

BULLETIN NO. 18.

Montana Agricultural Experiment Station

......OF......

THE MONTANA COLLEGE OF AGRICULTURE.

The Alkali Soils of Montana.

PRELIMINARY BULLETIN.

BOZEMAN, MONTANA, JUNE, 1898.

ROCKY MOUNTAIN HUSBANDMAN,
White Sulphur Springs,
MONTANA.

Montana Agricultural

EXPERIMENT STATION.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman.
Peter Koch, Secretary and Treasurer	Bozeman.
George Kinkel, Jr., Vice-President	Manhattan
Walter Cooper	Bozeman
Nelson Story	Bozeman

EXPERIMENT STATION STAFF.

S. M. Emery,	Director and Horticulturist.
F. W. Traphagen, Ph. D., F. C. S	Chemist.
E. V. Wilcox, Ph. D	Biologist.
Robt. S. Shaw, B. S. A.	Assistant Agriculturist.

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

Montana Experiment Station,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

MONTANA EXPERIMENT STATION.

Bulletin No. 18. *June, 1898.*

The Alkali Soils of Montana.

F. W. TRAPHAGEN.

INTRODUCTION.

By the term "Alkali Soil" is meant any soil in which excess of mineral salts soluble in water is present.

The salts which most commonly are present in alkali soils are the sodium carbonate, or "Sal Soda," which gives rise to "Black Alkali," and the sulfates, mainly of soda, which form the "White Alkali."

The former is present in but few localities, and in small quantity, in Montana, while the latter is widely distributed and exists in large quantities in many localities.

THE FORMATION OF SOIL.

Soils are formed by the disintegration of rocks. This disintegration is effected by various agencies; for example, by frost; by wind blown sands; by the erosive power of water and ice; by the solvent power of water, especially when aided by the presence of carbonic acid gas; by the chemical action of the atmosphere, and by other means.

The soil remaining after the action of these agents is that portion of the more or less finely ground material of the original solid rock, which is best able to resist the solvent action of the ever present water.

In its earlier stages the soil may consist of these finely ground relatively insoluble materials, with a solution of the more soluble materials thoroughly permeating its pores.

ORIGIN OF ALKALI.

All substances are more or less soluble in water, some in a very slight degree, as is the case with barium sulfate, which requires for the solution of one ounce four hundred thousand ounces of water; and some are extremely soluble, as sodium sulfate one part of which is soluble in two and one-third parts of water at the ordinary temperature.

In the process of rock disintegration it is rarely that any one of the disintegrating agents acts alone; usually one agent aids another.

When granite yields to the effects of frost its different constituents, quartz, feldspar and mica, are affected in varying degrees by the water which is always present in greater or less quantity. The relatively insoluble quartz, being composed of silica, which is one of the least soluble of substances, after the action of the solvents, is left behind in granules; the feldspar which contains considerable amounts of potash or soda, or both, is readily attacked by the solvent, which is usually water containing carbonic acid gas, forming with it carbonates which are easily soluble in water, and leaving the feldspar changed into clay; the mica is affected in a similar way.

Limestone is decomposed rapidly by water containing carbonic acid gas which takes into solution the lime, and leaves behind the less soluble silica and clay, which are the usual impurities of limestone. If there be small quantities of the alkalies, potash or soda, they are at the same time changed into soluble carbonates with the lime.

After these substances are changed partly into soluble materials, we have a mass, which usually consists of sand and clay, saturated with solutions of the soluble matters.

If the change has taken place in humid regions, the excess of water rapidly washes out the soluble materials and carries them to the sea. If, on the other hand, the soil has been formed in arid regions, no such agent is present to remove the carbonate of soda, for example, and there it remains, to be in time concentrated on the surface to form "Black Alkali."

SOURCE OF THE ALKALI.

My friend, Mr. Walter Harvey Weed, in charge of the U. S. Geological Survey work in Montana, who is more familiar with the geology of this State than any other person, suggested the probability of the source of the alkali in Montana localities being found in the Fort Benton shales, which were deposited in presence of salt or brackish water. This view was advanced with special reference to the alkali about Billings, but will be found to fit many other localities.

To test the accuracy of this opinion, I took samples along the bluffs of the Yellowstone river opposite Billings, where there are fine exposures of the Fort Benton shales.

The following results will show how well Mr. Weed's theory is supported by the facts, for it is to be remembered that the soils of the Yellowstone Valley at this point owe their origin largely to the disintegration of these shales. The analyses are of the material before it has become completely disintegrated:

	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
Lab. No. 641. Ordinary material of the bluffs opposite Billings, representing the products of the partial disintegration of the shales. Moist	1.03	.03
Lab. No. 642. Decomposed Fort Benton shales from bluffs opposite Billings.........	1.17	.03
Lab. No. 643. Slide mud on bluffs opposite Billings, all coated with white powder..................	2.02	.03
Lab. No. 644. Brick clay from top of bluffs opposite Billings—used for making brick	1.66	.03

It has been suggested that the water used for irrigation might bring large quantities of alkali upon the land irrigated by it, but this is not the case, for the irrigating water obtained from the Yellowstone river is very free from alkali salts.

THE GROUND WATER.

At a certain depth, varying in different localities, we find a point about which the water level fluctuates, sometimes the water line is below it, as is the case in dry weather, sometimes the water rises above its average height; especially is this true during the period of heavy spring rains. The water penetrates the soils, occupying all the interstices up to the point just mentioned, and the irregular plane connecting different points of this underground water surface is known as the "water table."

With the advent of irrigation, unless the underdrainage be very perfect, the ground water begins to rise, and with it brings all the alkali contained in the soil through which it passes, concentrating it in the upper parts of the soil.

Many plants of which alfalfa is a type, cannot successfully withstand the presence of the permanent water table too near the surface, and the approach of the water to within a few feet of the surface is promptly followed by the killing out of the alfalfa.

The following examples strikingly illustrate the rise of the ground water in the valley above Billings:

Mr. Hiram Abshire dug a well in 1882 and was compelled to go down thirty-one feet to reach water. Since this time the water in the well has been within three feet of the surface; in September, 1897, the water was only six feet below the surface of the ground.

Mr. Samuel Holmesland found water within six feet in the fall of 1896; in the irrigating season the water rose to within two feet of the level of the ground.

Mr. E. P. Searles dug a well in the spring before irrigating began; at twelve feet no water was found and well was abandoned. In the fall after irrigation was started the well filled completely with water.

Mr. T. C. Armitage found water eight years ago at a depth of fifteen feet, the water now stands four feet from surface.

THE RISE OF THE ALKALI.

When water in the course of irrigation, or during rain, sinks into the ground, it dissolves soluble materials in its downward course. Such salts remain in solution until removed by chemical action, for it is a well known fact that filtration through soil, or even the most perfect of artificial filters, fails to remove anything except it be in the form of suspended solid particles. These salts return to the surface of the soil when, by capillary action, water is brought up to supply that lost by surface evaporation; as evaporation continues, more and more water rises to the surface bringing always with it its quota of dissolved material.

As the water evaporates the salts are left behind on the surface, forming, when in sufficient quantity, the white crusts seen in badly alkalied places. It is an unfortunate fact that none of this salt evaporates with the water, but that it all remains behind in the upper part of the soil to be gotten rid of as best we may.

It is altogether probable that ranches lying below the level of others may, through excessive irrigation above, have the level of their water tables raised, at the same time the excessive amounts of water, derived from irrigation of other ranches, may and probably will, carry with it more or less alkali into the soil of ranches on lower levels.

REMEDIES.

Underdrainage—If it were not too expensive, this would be the method to be used in all cases, for, when properly conducted, it is impossible for the ground water to rise, and all excess of water carrying with it dissolved salts, obtained in its downward course through the soil, instead of being allowed to come to the surface again, evaporate and leave the salts where they will do the most harm, is compelled to pass off through drains and to carry its salts with it.

But for many years to come, cheaper, even if less thorough, methods must be used, except possibly in especially favored localities.

Surface Flooding—When my attention was first brought to the seriousness of the alkali problem, I suggested that there might be favored localities where water could be quickly passed over the land in large quantities and as quickly removed. Attention was especially directed to the fact that if the water was allowed to stand, that instead of improving conditions, the reverse effect might be expected. This suggestion was practically tried with success in a few cases, but last June, Nature tried the same experiment on a grand scale, with what success the following figures, kindly furnished by Mr. Thos. Means, will show:

Soluble salts removed hourly.	Percent salts.	Tons salt per hour.
Billings Town Ditch, June 4th, 40 cu. ft. per sec.	.302	13.6
Billings Town Ditch, " 6th, " " "	.424	19.1
Billings Town Ditch, " 7th, " " "	.422	19.0
Billings Town Ditch, " 11th, " " "	.440	20.2
Billings Town Ditch, " 12th, " " "	.283	12.7
Billings Town Ditch, " 13th, " " "	.481	21.6
Billings Town Ditch, " 16th, " " "	.227	10.2

The average amount of alkali removed daily, for the twelve days that these observations covered, was four hundred tons, or four thousand eight hundred tons for the short period covered by the experiment.

This is no inconsiderable amount, and in time its effect must be noticed. It should be our province to supplement the work of Nature so far as possible and along similar lines.

By Judicious Selection of Crops--As has been said before, surface evaporation must be prevented as far as possible, and crops should be planted with this aim in view.

This can be done in either of two ways, first, by planting a crop like corn, or sugar beets, which requires frequent hoeings or cultivations; this treatment leaves the soil in a condition where evaporation is least marked; or, second, by seeding some crop like alfalfa, which in its growth, so completely protects the ground from the direct influence of the sun's rays, as to reduce evaporation to a minimum degree.

In the notes accompanying the analyses will be found remarks calling attention to the surprising results found in soils where alfalfa was successfully growing.

Limiting the Use of Water—Enough has already been said to show the importance of using as small an amount of water as will serve the needs of the crops. There is a prevailing belief among those who have most carefully studied the subject, that in general we use far more water in irrigation than is necessary, and of all places where economy should be practiced, there is none requiring it more than that place where excessive use brings ruin to the soil.

EFFECTS OF ALKALI UPON PLANTS AND SOILS.

When the "black alkali" reaches about one-tenth of one per cent. in the soil its pernicious effects begin to be seen. About the stems of plants, or wherever the alkaline solution comes in contact with the vegetable matter, the material is corroded and dissolved, leaving the stem frequently completely girdled.

On account of its solvent effect upon vegetable matter, it dissolves the humus, or vegetable mold, contained in the soils, forming dark colored solutions and depositing a black residue upon the evaporation of the water, which gives rise to its name "black alkali."

But beside the two very objectionable qualities mentioned, the sodium carbonate has the further effect of destroying the tillability of many soils, especially those containing a predominance of clay, so that it is almost impossible to reduce to a condition of perfect tilth again a clay soil which has been charged with this alkali.

The "white alkali" or sodium sulfate, acts in an entirely different manner, and much more of it may be present in the soil than could be permitted with sodium carbonate, before baleful effects are noticed. While most excellent crops may be taken from the ranche, usually the best in its history, just before the alkali completely destroys the crops, still these substances, which are many of them good plant foods when present in moderate quantity, are in their effects rank poisons when present in excess.

One explanation offered to illustrate the action of these salts, is based upon the fact that all mineral food is obtained by the plant through the process of osmose, which is the name given to the passage of solutions through porous partitions or cell walls. The flow of liquid is more rapid from the point where the liquid is least dense, to the part where it is most dense; in the case of alkali soils, the water in contact with the roots is so much more dense than the plant liquids, that instead of a passage of food containing water from without into the plant, the reverse process sets in, and the plant actually starves in the midst of plenty to eat and drink.

In this connection it is interesting to draw attention to the fact that a number of buildings in Billings, the foundations of which are of a porous sandstone, are gradually becoming insecure, because of the disintegration of the rock due to the absorption of alkaline salts, followed by the evaporation of the water, and the deposit of salts within the pores of the rock; as the process continues and more and more salts are deposited, the rock particles are forced apart and give way, the rock crumbling to pieces.

THE VEGETATION OF ALKALI FLATS.

The following list of plants, collected from an alkali flat west of the Armitage ranche, may be taken as characteristic of the vegetation of such places in Montana. I am indebted to Dr. J. W. Blankinship, the Botanist of our Experiment Station, for the determination of the species:

The plants were collected Aug. 28, 1898.

Chenopodium glaucum, L.	(Pigweed).
Panicum capillare, L.	(Panic grass).
Panicum crus-galli, L.	(Panic grass).
Xanthium canadense echinatum, Gray.	(Cocklebur).
Grindelia squarrosa, Dunal	(Gum plant).
Hordeum jubatum, L.	(Squirrel tail grass).
Agropyrum dasystachyum, Scribn.	(Blue joint).
Suaeda depressa, Wats	(Sea blite).
Aster angustus, T. & G.	(Aster, Starwort).
Plantago Asiatica, T. & G. (?)	(Plantain).
Polygonum littorale, Link	(Knotweed).
Distichlis maritima, Raf	(Spike grass).

COMPOSITION OF MONTANA ALKALI.

The alkali found in this State, especially where most of our work has been done, is almost without exception the "white alkali." The reason for the great predominance of the white alkali is to be found in the widespread distribution of gypsum, which has the power of changing the "black alkali" to white.

In the table following the composition of the alkali is given. It will be noticed that while the percentage of the constituents vary in the different samples, the ratios the different salts bear to each other is remarkably constant. This would indicate a common origin for all.

The calcium sulfate of the table corresponds to dissolved gypsum, the magnesium sulfate to Epsom salt, the sodium sulfate to Glauber's salt, the potassium sulfate to sulfate of potash, the sodium nitrate to Chilian saltpeter and the sodium carbonate, in terms of which the alkalinity is expressed, to sal soda.

TABLE OF COMPLETE ANALYSES.

Lab. No.	DESCRIPTION.	Silica	Calcium Sulfate	Magnesium Sulfate	Potassium Sulfate	Sodium Sulfate	Sodium Nitrate	Sodium Chloride	Alkalinity in terms of Sodium Carbonate
304	S. Holmesland surface crust	.054	1.28	14.91	.83	26.65	Trace	.637	.144
343	L. Nutting	.016	.05	.02	.02	.50	Trace.	.116	.192
372	Hesper Farm, 14th foot	.004	.15	.13	.009	.32	.0182	0	.096
392	Alkali field opp. Morgan's, 1st inch	.018	.61	1.90	.06	2.89	Trace.	.116	.096
405	P. B. Moss, 1st in.	.035	1.38	3.21	.18	6.43	.091	.578	.048

TABLES OF ANALYSES.

The tables of analyses which follow show the composition of the soil at various depths.

Usually notes concerning the character of vegetation, the amount of moisture present, etc., accompany the analyses so that a basis of comparison may be had for use in determining various matters of interest in this study.

Comments are made after many of the tables and especial attention should be given them, for the practical results of the study up to this point are contained therein.

As many hundred samples were to be analyzed, it became necessary at the outset, to adopt a system by means of which the relative amount of soluble salts present in each could be readily determined. After learning that the salts were practically all present as sulfates, and that sodium was the principal base, and moreover, that the proportions of the bases remained practically constant, it was determined to calculate the sulphuric acid found to sodium sulfate, or Glauber's salt, and the alkalinity to sodium carbonate or sal soda and in the following tables these salts are made the basis of comparison:

SAMPLES FROM BILLINGS AND VICINITY.

Ed. Cardwell, N. W. ¼, Sec. 2, T. 1 S., R. 25 E. Five miles west of Billings, Montana. Sampled in alfalfa field where growth was tolerably fair.

Lab. No.	Depth of Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
221	0 to 12	.140	.017
222	12 to 24	.198	.014
223	24 to 36	.039	.014
224	36 to 57	.036	.014
225	57 to 72	.036	.017
226	72 to 90	.039	.017
227	90 to 108	.037	.010

Ed. Cardwell, N. E. ¼, Sec. 3, T. 1 S., R. 25 E. Five miles west of Billings, Montana. Sampled in bare unirrigated field west of and across the road from previous sample. Crop blue grass, very poor, field used for pasture.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
228	0 to 12	.043	.017
229	12 to 24	.063	Trace
230	24 to 36	.130	.017
231	36 to 57	.150	.010
232	57 to 72	.160	.017
233	72 to 90	.166	.017

A comparison of these last two sets of samples will illustrate in a striking manner the effects of irrigation in concentrating the alkali near the surface. In the first lot where the field was irrigated, sixty-four per cent., nearly two-thirds of all the alkali contained in nine feet of soil, concentrated in the first twenty-four inches; in the second lot, but fourteen and nine-tenths per cent., about one-seventh, of the alkali contained in seven and one-half feet of soil, is found in the first two feet.

This is an impressive lesson on the importance of using as little water in alkali districts as will suffice.

Alkali field south of and across road from Hiram Abshire's ranch house. N. W. ¼, Sec. 19, T. 2 S., R. 24 E. Bare spot showing white places. There was practically no living vegetation present. Surface crust of alkali is from ½ in. to ¾ in. thick which breaks free from underlying pulverulent material. This combination of crust and pulverulent material seems to be almost a perfect protection to the underlying soil against evaporating influences, for wherever both are found the soil is always moist underneath.

Lab. No.	Depth in inches.	Per cent. of Sodium Sulfate.	Per cent. of Alkalinity in terms of Sodium Carbonate.	Per cent. water.
282	Surface Crust ¼ to ¾ in.	7.39	Trace	2.80
283A	Pulverulent Mat. 0 to 1 in.	4.44	Trace	14.84
283B	1 to 7 in. moist clay.	2.12	Trace	22.17
284	7 to 13	1.11	Trace	20.40
285	13 to 25	.86	Trace	
286	25 to 37, sand	.54	Trace	20.90
287	37 to 49, clay	.53	Trace	
288	49 to 61, sand, saturated.	.79	Trace	

Hiram Abshire, S. W. ¼, Sec. 18, T. 2 S., R. 24 E. Samples taken in alfalfa field, good crop; sampled north of his house, about ¼ mile from place where samples Nos. 282, 288 were taken. Field had been in alfalfa 3 years, sampled after third cutting; soil barely moist, sandy.

Lab. No.	Depth in Inches.	Per cent. of Sodium Sulfate.	Per cent. of Alkalinity in terms of Sodium Carbonate.	Per cent. water.
289	0 to 12	.134	Trace	8.60
290	12 to 24, sandy.	.130	Trace	14.10
291	24 to 36.	.090	.021	14.60
292	36 to 60, moist.	.110	.021	17.70
293	60 to 72, very moist.	.080	.025	18.02
294	72 to 84, very moist.	.050	.025	
295	84 to 96, sandy, saturated.	.070	.028	

Samuel Holmesland, N. E. ¼, Sec. 13, T. 2 S., R. 24 E. Sampled in oat field about 300 yards south of house. Cultivated 4 inches deep and sowed to oats with good yield. Originally was a native blue stem meadow.

Lab. No.	Depth in Inches.	Per cent. of Sodium Sulfate.	Per cent. of Alkalinity in terms of Sodium Carbonate.	Per cent. water.
296	0 to 12, loam (lost sample)			11.20
297	12 to 24, slightly moist.	.075	.028	11.40
298	24 to 36, more clay, more moist.	.111	.032	15 80
299	36 to 48.	.210	.028	16 60
300	48 to 60.			17.90
301	60 to 72, sand saturated.	.466	.021	21.03
302	72 to 84, saturated quicksand.	.824	.017	
303	84 to 108, hole filled in.	.827	.028	

We were unfortunate enough to lose some of our samples this season in shipment. The samples were first packed in tough paper bags, the kind used for nails, but being handled roughly in transit many of the sacks were torn apart and the contents lost. After this experience we used cloth sacks.

Badly alkalied field east of the former one, formerly Fred Sanford's field. No vegetation, surface covered with alkali crust. N. W. ¼, Sec. 18, T. 2 S., R. 24 E.

Lab. No.	Depth in Inches.	Per cent. of Sodium Sulfate.	Per cent. of Alkalinity in terms of Sodium Carbonate.	Per cent. water.
304	Surface crust.	45.56	.187	
305	1 inch below crust, lost.			
306	2 to 12	1.28	.017	20.40
307	12 to 24	.69	.025	
308	24 to 36	.56	.028	
309	36 to 48, water.	.42	.028	
310	48 to 60.	1.13	.021	

E. P. Searles, N. E. ¼, Sec. 22, T. 2 S., R. 23 E. Samples taken in timothy field about ¼ mile north-west of his farm house. No signs of alkali on surface. Field irrigated five days before sampling. No grass grew on this field until water was brought on it when a wonderful yield was raised, nearly two tons to the acre.

Timothy seed was thrown on surface with no dragging or harrowing. Blue Stem played out in 7 years. Timothy sown before Blue Stem gave out.

Samples were taken ½ mile north of break of hill.

Lab. No.	Depth in Inches.	Per cent. of Sodium Sulfate.	Per cent. of Alkalinity in terms of Sodium Carbonate.
311	0 to 12, clay.	.086	.021
312	12 to 24.	.076	.025
313	24 to 36, occasional pebbles.	.057	.025
314	36 to 48.	.081	.017
315	48 to 60, water, gravel.	.110	.017

Mr. Searles advances the theory that because of the break in the small elevation, about ½ mile due south of point where sample was taken, the rise of the ground water and hence of the alkali is prevented. It is more probable, however, that the substratum of gravel permits of perfect underdrainage and that the small amount of alkali present is because of this.

C. C. Steers, N. W. ¼, Sec. 14, T. 2 S., R. 23 E. Alkali shows in white patches on knolls on highest points. Failed to get water over these places. Where water failed to run, there was no grain; below there was a good yield. Alkali on highest points only.

Samples taken in oat field about 300 feet south-west of farm house. Field in oats for last 5 years with good crops.

Lab. No.	Depth in Inches.	Per cent. of Sodium Sulfate.	Per cent. of Alkalinity in terms of Sodium Carbonate	Per cent. water.
316	0 to 12, sandy loam, moist,	.068	.007	10.05
317	12 to 24, sandy loam,	.041	.032	14.10
318	24 to 36, " "	.085	.032	16.80
319	36 to 48, " "	.037	.025	18.30
320	48 to 60, " "	.063	.028	19.40
321	60 to 72, " "	.048	.035	17.80
322	72 to 84, water, sand. 8th and 9th feet sandy.	.044	.021	

This is another case in which immunity from alkali is probably due to character of the underlying material. Sand is readily permeable by water.

Fred Sanford, N. E. ¼, T. 2 S., R. 23 E. Sampled in bean field about 100 feet from main road, and west of gate. Cultivated 8 or 9 years. Very fine crops always grown. No evidence of alkali on surface. Not irrigated this season.

Lab. No.	Depth in Inches	Per cent. of Sodium Sulfate.	Per cent. of Alkalinity in terms of Sodium Carbonate.	Per cent. water.
323	0 to 12	.039	.021	4.70
324	12 to 24, sandy.	.047	.028	5.70
325	24 to 36, dry, slightly clayey, part gravelly.	.057		15.20
326	36 to 48, moist.	.045	.007	16 60
327	48 to 60, sandy.	.046	.025	10.20
328	60 to 72, sandy. 7th foot sandy, and 8th and 9th feet coarse sand.	.049	.048	17.70

Chas. D. Camp, S. W. ¼, Sec. 8, T. 2. S., R. 24 E. Sampled in alfalfa field 50 feet south of S. W. corner of hay fence, and 15 feet from ditch. Cultivated 11 years, last 5 years to alfalfa. Yield 5 tons per acre, soil is a loam of fine texture and apparently just right as to moisture. Alkali did not appear in alfalfa field but showed very plainly at his house a few hundred feet north of where samples were taken.

Lab. No.	Depth in Inches.	Per cent. of Sodium Sulfate.	Per cent. of Alkalinity in terms of Sodium Carbonate.	Per cent. water.
329	0 to 12	.056	.025	9.70
330	12 to 24, loam, lower inch clay,	.043	.028	10.60
331	24 to 36, clayey loam,	.077	.039	11.61
332	36 to 48, clayey loam,	.220	.043	12.60
333	48 to 60, clayey, white spots,	1.410	.010	13.20
334	60 to 72, clayey, white spots,	1.600	.014	15.10
335	72, ¼ mile south of above, more moist,	1.22	.007	

I wish to draw especial attention to this series, and to others where the ground water is six feet or more deep, and where alfalfa has secured a good stand, This crop has a remarkable power to prevent the rise of the alkali, and would seem to slowly remove it, for the very heavy crops, containing a considerable amount of mineral matter, a large portion of which is alkali salts, must remove very large quantities of alkali in the aggregate. My observations have caused me to believe that if a stand of alfalfa can be secured, and the water table kept low enough, that for all fields where such conditions prevail the alkali problem is solved.

Lew Nutting, S. W. ¼, Sec. 10, T. 2 S., R. 24 E. Sampled in alfalfa field about 150 feet northeast ot house. Poor yield.

Lab. No.	Depth in Inches.	Per cent. of Sodium Sulfate.	Per cent. of Alkalinity in terms of Sodium Carbonate.
336	0 to 12, clayey,	.099	.028
337	12 to 24, clayey and pebbles, lower portion dryer,	.19	.021
338	24 to 36,	.14	.007
339	36 to 40, at 3⅓ feet, stopped by rocks,	.49	.014

Lew Nutting. Sampled in clover field about 300 yards northeast of house and fifty feet from fence. No stand. Manured.

Lab. No.	Depth in Inches.	Per cent. of Sodium Sulfate.	Per cent. of Alkalinity in terms of Sodium Carbonate.
340	0 to 12,	.13	.017
341	12 to 24,	.46	.010
342	24 to 36, Occasional white spots,	.92	Trace
343	36 to 48, Occasional white spots,	4.88	.028
344	48 to 72,	1.10	.017
345	72 to 84, White crystals,	1.04	.021
346	84 to 96,	.38	.028
347	96 to 108, Sand, water,	.23	

Field East of Lew Nutting's, Section 11, S. R. 24, T. 2, S. E. Quarter.

Uncultivated, unirrigated, sampled in center of field.

Lab. No.	Depth in Inches,	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
747	0 to 12 fairly dry.	.084	.077
748	12 to 24 moist.	1.01	.067
749	24 to 36 more moist.	1.13	.056
750	36 to 42 "	1.07	.056
	Gravel at 8¼ feet, very near water.		

Lew Nutting's lower ranch, Aug. 26, 1898. Formerly grew timothy, now shows strong effloresence on surface. Alfalfa failed to stand.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
751	0 to 12 moist.	1.92	.056
752	12 to 24 moist gravel.	.69	.060

Lew Nutting, Aug. 26, 1898. South of preceding (751). Sown to Alfalfa. Conditions, as far as known in two portions sampled, are identical, yet the portion on which alfalfa grows very well, is divided from portion containing no alfalfa, by a sharp line of demarcation. Sown to oats preceding season with similar results.

Alkali shows on surface on one portion considerably and slightly on the other. Ten paces north of line good stand of alfalfa.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
753	0 to 12	.59	.060
754	12 to 24	.65	.046
755	24 to 36, water.	.17	.073
	Ten paces south of line alfalfa dead.		
756	0 to 12	.92	.056
757	12 to 24	.82	.046
758	24 to 33, gravel.	.23	.063

Dr. Nutting's old ranch, N. W. ¼, Section 14, T. 2 S., R. 24 E. Ten rods south of Clark's Fork ditch and 36 feet east of fence. Twelve years in alfalfa.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
759	0 to 12	.06	.077
760	12 to 24	.53	.068
761	24 to 36	1.07	.056
762	36 to 48	1.34	.060
763	48 to 60	1.28	.053
764	60 to 72	1.26	.056
765	72 to 84	.40	.083
766	84 to 96	.25	.100
767	96 to 108	.14	.110

Hesper Farm, N. E. ¼, Sec. 13, T. 1 S., R. 24 E. Sampled in uncultivated, unirrigated land above ditch, 300 yards from ditch, 200 yards from Canyon Creek. Vegetation is bunch grass and cactus. Water was used in the hole at the 7th foot on account of falling off of sample. Near south section line.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.	Percent water.
359	0 to 12 dry fine sand.	.016	.025	8.40
360	12 to 24 " sand.	.006	.021	4.30
361	24 to 36 " fine sand.	Trace	.032	8.50
362	36 to 48 " "	.015	.021	3.50
363	48 to 60 " "	.045	.017	
364	60 to 72 " "	.077	.014	
365	72 to 84 " "	.094	.021	
366	84 to 96 " "	.123	.014	
367	96 to 108 sand	.104	.014	
368	108 to 120 sand and clay at bottom.	.115	.025	
369	120 to 132 clay.	.288	.021	
370	132 to 144 "	.379	.017	
371	144 to 156 "	.737	.010	
372	156 to 168 " white salt	.780	.017	
373	168 to 180 salt, sand at bottom.	.745	.014	
374	180 to 192 sand, clay, sand and salt at bottom.	.605	.017	
375	192 to 204 sand	.574	.014	
376	204 to 216 "	.458	.010	

This series shows the conditions which prevail before irrigation takes place. At some zone, more or less deep, there is a heavy concentration of the alkali. The alkali salts are usually present in such quantities in these bands as to be different in appearance from the soil, being of lighter color, generally nearly white and frequently in the form of crystals. There is comparatively little alkali in these undisturbed soils, except in or near this zone of concentration.

Hesper Farm, N. E. ¼, Sec. 18, T. 1 S., R. 25 E. Sampled in alfalfa field north of gate near road.

Field planted to alfalfa 13 years ago. Alkali showing in road and field to the east.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.	Percent water.
377	0 to 12 sand.	.012	.017	11.50
378	12 to 24	.004	.021	11.70
379	24 to 36	.015	.028	12.60
380	36 to 48	.013	.025	
381	48 to 60 clayey	.013	.025	19.00
382	60 to 72	.019	.039	
383	72 to 84	.031	.039	19.5
384	84 to 96 sand, water.	.054	.032	

This field presents another instance of the beneficent effects of alfalfa, and the analyses studied in conjunction with the knowledge of the fact, that but a few feet away from the alfalfa field, the pernicious effects of the alkali are already marked, cannot fail to support the case of the claims of alfalfa as the ideal crop for alkali regions.

Hesper Farm Smoke House, N. W. ¼, Sec. 18, T. 1 S., R. 25 E.

Samples taken from south side. Alkali shows from 3d foot to 5½ feet. This point is below and not far from main ditch.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
385	0 to 12	.019	.025
386	12 to 24	.055	.039
387	24 to 26	.130	.035
388	36 to 48	.38	.017
389	48 to 60	.48	.014
390	60 to 66	.16	.035
391	66 to 72	.14	.035

Alkali Field, S. E. ¼, Sec. 3, T. 1 S., R. 25 E. Located due west of Mr. Morgan's house.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
392	0 to 1	5.11	.058
393	1 to 12	.81	.021
394	12 to 24	.20	
395	24 to 36	.15	.046
396	36 to 48	.63	.025
397	48 to 60	.60	.014
398	60 to 72	.30	.028

Section 11. Samples taken 500 feet east of Shiloh school house and 50 feet from fence. This is a blue joint field showing alkali a few feet west of the place where samples were taken. Blue joint was doing very poorly.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
399	0 to 12, clay	.73	.035
400	12 to 24	.70	.042
401	24 to 36	.95	.049
402	36 to 48	1.69	.014
403	48 to 60	1.08	.007
404	60 to 72, water.	.76	.014

W. H. Gardner, 10 acre farm on the west edge of Billings. Sampled in garden about 150 feet from house, in cabbage patch.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
411	0 to 12	.06	.021
412	12 to 24	.98	.007
413	24 to 36	.61	.017
414	36 to 48	.63	.021
415	48 to 60, water at bottom.	.72	.010
416	60 to 72	.65	.021

E. B. Hastings, S. W. ¼, Sec. 24, T. 1 S., R. 24 E. Sampled in alfalfa field, new seeding, poor stand. Previous crop native blue joint.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
348	0 to 12	.043	.032
349	12 to 24	.035	.032
350	24 to 36	.039	.042
351	36 to 48	.031	.028
352	48 to 72	Trace	.007
353	72 to 84	Trace	.007
354	84 to 96, white salt	.073	Trace.
355	96 to 108 " "	.065	.014
356	108 to 120, sand, white salt	.34	.007
357	120 to 132, "	.15	.007
358	132 to 144, "	.30	.007

Harry Ramsey, S. W. ¼ Sec. 1, T. 1 S., R. 25 E. Aug. 27, 1898. Field nearest house, nearly north of house. N. W. corner of alfalfa field, replaced by foxtail, etc.

Dug well ten years ago. Water was found at 15 or 16 feet, now four feet to water.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
796	0 to 12, moist.	1.56	.070
797	12 to 24 "	.62	.070
798	24 to 36 "	.27	.073
799	36 to 48 "	.21	.063

Harry Ramsey, Aug. 27, 1898. Alfalfa field four years old, only irrigated once in four years. Second crop cut Ang. 17th. Field nearest town across ditch from house. He believes that the heavy spring rains did him more harm than good.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
792	0 to 12, moist	.05	.067
793	12 to 24	.50	.073
794	24 to 36	.22	.067
795	36 to 48, water	.11	.073

T. C. Armitage, Aug. 27, 1898. Alfalfa field N. E. of barn, best portion, good crop.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
805	0 to 12	.02	.073
806	12 to 24	.04	.083
807	24 to 36	.24	.077
808	36 to 48	.88	.053
809	48 to 60	.52	.053
810	60 to 72, water	.07	.080

T. C. Armitage, Aug. 27, 1898. Sampled at north side of ranch where alfalfa is killed out. Formerly there was a good stand. North of barn there is a white efflorescence.

Well 15 feet deep; now 4 feet to water; dug 8 years ago; then 15 feet to water.

It is believed that Armitage's alfalfa receives excess of water, and that this is the cause of killing.

Lab. No.	Depth of Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
800	0 to 12, moist, white spots	2 01	.056
801	12 to 24	1.27	.063
802	24 to 36	.64	.073
803	36 to 48	.86	.046
804	48 to 60, water	.63	.053

Ed. O'Donnell, Aug. 25, 1898. Sugar beet patch.

Ground moist at lower points of field, only occasional plants are living. Some clay present in first foot.

Lab. No.	Depth in Inches.	Per cent. of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
730	0 to 12	.82	.028
731	12 to 24	.58	.035
732	24 to 36, water	.26	.060

Ed. O'Donnell, Aug. 25, 1898. Sugar beet patch, upper end.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
733	0 to 12	.05	.035
734	12 to 24	.04	.063
735	24 to 36, water 2½ feet	.07	.063

Ed. O'Donnell, Aug. 25, 1898. In clover field. Crop doing excellently at sampling point and at most other places, occasional barren spots.

Lab. No.	Depth in Inches.	Per cent. of Sodium Sulfate.	Per cent. of Alkalinity in terms of Sodium Carbonate.
736	0 to 12	.08	.035
737	12 to 24	.08	.053
738	24 to 36, 3½ ft. water	.06	.073

Lew Nutting, Aug. 26, 1898. Excavation for addition to kitchen.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
739	0 to 4, sandy	.29	.049
740	4 to 12	.07	.063
741	12 to 24	.08	.080
742	24 to 30	.03	.070
743	30 to 40	.10	.070
744	40 to 48	.51	.056
745	48 to 56	.48	.063
746	56 to 64	1.99	.053

Ed. O'Donnell's ranch. Alfalfa killed out. Red patches, with fox tail.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
768	0 to 12	.90	.046
769	12 to 24	.72	.060
770	24 to 36, 2½ feet water	.27	.083

Same field as above. Good crop of alfalfa.

771	0 to 12	.31	.08
772	12 to 24	.32	.10
773	24 to 36, water	.34	.07

Same field a few feet north, barren red place crusted with alkali. Water did not flow over surface.

774	Surface crust	29.98	.126 Solution colored.
775	0 to 12	1.30	.049
776	12 to 24	.93	.077
777	24 to 36, water	.42	.083

Ed. O'Donnell, Aug. 29, 1898. Corn field, section where corn is doing badly, not growing at all in places. White powder on ridges.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
821	0 to 12. moist	.85	.073
822	12 to 24 "	1.94	.073
823	24 to 36. crystals of salt, last 3 inches sand	1.59	.060
824	36 to 48. crystals	1.50	.053
825	48 to 54, water	1.12	.053

Thirty paces east of preceding.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
826	0 to 12. dryer than above	.04	.049
827	12 to 24 " "	.34	.060
828	24 to 36, sandy	.65	.083
829	36 to 48, water	.64	.077

P. B. Moss, S. ½, Sec. 5, T. 1 S., R. 26 E. Location of ranch one mile west of Billings, Mont. Sampled about 200 feet from main road. Ground just being plowed. These samples were taken in September, 1897, and appearances were not favorable for a crop during the next season.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
405	0 to 1. surface crust	9.91	
406	1 to 12	.81	.014
407	12 to 24	.64	.017
408	24 to 36. water	.28	.028
409	4th to 5th foot	.21	.032
410	60 to 72	.22	.032

P. B. Moss, Aug. 24, 1898, 1 mile west of Billings. Slope of hill west of alkali flat. Upper six inches of first foot dry; lower six inches shows some signs of moisture.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
706	0 to 12	.14	.025
707	12 to 24. moist	.89	.032
708	24 to 36. more moist	.52	.042
709	36 to 54.	.57	.039
710	54 to 72.	.66	.056

Water at 5 feet.

P. B. Moss, Aug. 24, 1898. Second locality, opposite side, (15 feet) of ditch in alfalfa field. Very fine patch.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
711	0 to 12, nicely moist,	.53	.021
712	12 to 24, more moist,	.33	.039
713	24 to 36,	.18	.056
714	36 to 46, water	.21	.046

P. B. Moss, Aug. 24, 1898. Third location fifty feet east of last point, alkali showing in places. Poorer yield of alfalfa than preceding.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
715	0 to 12	1.15	.028
716	12 to 24, more moist,	.95	.039
717	24 to 36, 3½ feet water,	.72	.039

P. B. Moss, Aug. 24, 1898. Fourth location, 18 paces east of preceding location. Alfalfa nearly all dead, occasional thrifty plants; sampled near west end of alkali spot.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.	
718	Surface crust ½ inch, pulv.	13.91	.032	Solution slightly colored
719	0 to 12,	1.27	.025	
720	12 to 24,	.78	.049	
721	24 to 36, quicksand, water,	.52	.042	

P. B. Moss, Aug. 24, 1898. Fifth location, east of the other places. Absolutely barren ground, good stand of alfalfa in spring, died out about July 24, 1898.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
722	Surface crust,	35.07	.053
723	0 to 12,	1.03	.028
724	12 to 24,	1.30	.025
725	24 to 36, white spots	1.24	.032
726	36 to 42, water	.99	.032

P. B. Moss, Aug. 25, 1898. Sixth location. Alfalfa just living.

Lab. No.	Depth in Inches,	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
727	0 to 12,	1.75	.021
728	12 to 24,	1.16	.039
729	24 to 36, water,	.96	.049

Lake Basin, west of Twin Lakes, Sec. 34, T. 2 N., R. 22 E., Aug. 28, 1898.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
811	0 to 12, slightly moist,	.85	.077
812	12 to 24, slightly moist, white crystals,	1.93	.056
813	24 to 36, slightly moist, white crystals,	2.50	.046
814	36 to 48, moist,	1.90	.046
815	48 to 60, white pebbles,	.31	
816	60 to 72, very moist,	.20	
817	72 to 84, very moist,	.12	
818	84 to 96, very moist,	.70	.053
819	96 to 108,	.06	
820	108 to 120,	.05	

Warm Springs, Montana, June 30th, 1898. Samples from E. 645 to 659 were taken on land of Mitchell & Mussigbrod near Insane Asylum. This set of samples was taken from north side of excavation for new laundry of asylum. Very light colored, nothing growing on surface in yard, where no attempts at culture have been made.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
645	0 to 12, light colored,	2.54	.08
646	12 to 15, gravel and sand, roots to this depth,	1 08	.08
647	15 to 42, to gravel, light colored streaks,	3.48	.10

Mitchell & Mussigbrod, Warm Springs, Montana, June 30, 1898. Southwest corner of oat field west of water tank of railroad. Sampled 25 feet from corner diagonally. Fair stand of oats. Ground moist at this point, which is near entrance of water to the field. About ¾ of this field is barren.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
648	0 to 6, dark soil,	4.26	.09
649	6 to 12, light soil,	2.26	.08
650	12 to 24, light soil,	2.18	.07
651	24 to 31, light soil,	2.66	.12
652	31 to 36, dark soil, gravel,	6.04	.13

Mitchell & Mussigbrod, Warm Springs, Montana, June 30, 1898. Same oat field, 55 feet north of south fence and 115 feet east of west fence. Alkali shows heavy on surface, occasional spears of oats.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Pecent of Alkalinity in terms of Sodium Carbonate.
653	Surface efflorescence,	39.65	.28
654	0 to 6, dark soil, moist,	4.87	.09
659	6 to 12, light, moist,	2.37	.02
655	12 to 24, light, moist,	2.38	.07
656	24 to 36, light, moist,	2.23	.07
657	36 to 42. moist,	3.02	.09
658	42 to 44, dark, moist, gravel, water,	2.65	.09

Samples from Montana Experiment Station, Aug. 6, 1898. Location No. 1, Forestry Nursery, marked by stake.

Lab. No.	Depth in Inches.	Per cent of Sodium Sulfate.
660	0 to 12	.024
661	12 to 24, white spots,	.32
662	24 to 36,	.29
663	36 to 48,	.47
664	48 to 60,	.17
665	60 to 72, water 5¼ feet,	.14

Location No. 2, in Forestry Nursery, marked by stake. Soil 9 inches deep. Water 6 feet. Gravel 9 feet 4 inches. Aug. 6, 1898.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.
666	0 to 12,	.03
667	12 to 24,	.15
668	24 to 36,	.33
669	36 to 48,	.22
670	48 to 60,	.05
671	60 to 72,	.11

Location No. 3. Prairie east of Forestry Nursery. Aug. 6, 1898. E. 672 to 679.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate
672	0 to 6,	.02
673	6 to 12,	.03
674	12 to 24,	.13
675	24 to 36,	.12
676	36 to 48,	.03
677	48 to 60,	.03
678	60 to 72,	.03
679	72 to 108, 9th foot water.	.02

Aug. 6, 1898. Location No. 4, clover field, 20 acres, southwest corner of farm. Soil 12 inches deep. Gravel 51 inches.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.
680	0 to 12,	.015
681	Subsoil,	.017

Aug. 6, 1898. Location No. 5, clover field west of Station building. Soil 12 inches deep. Heads of clover mostly dead in small patch, rest of plant thrifty. Clover left for seed.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.
682	0 to 12,	.017
683	12 to 24, moist,,	.08
684	24 to 36,	.04
685	36 to 42, gravel and water,	.023

Aug. 6, 1898. Miscellaneous samples. Location No. 6, clover field, N. W. corner of farm, more moist than location No. 5. Gravel and water 3 feet.

Lab. No.	Description.	Percent of Sodium Sulfate.
691	Soil,	.017
692	Subsoil,	.015

Aug. 6, 1898. Analyses of Rotation Plat samples.

Lab. No.	Description.	Percent of Sodium Sulfate.
694	Plat No. 1, wheat, soil 1 ft. deep, gravel 3 ft. to 9 ft.	.013
700	Subsoil,	.005
695	Plat No. 2, peas. soil 10 inches, gravel 4½ feet,	.006
696	Plat No. 3, oats, soil 9 in., gravel 3½ ft.,	.017
702	Subsoil,	.005
697	Plat No. 4, beets, soil 10 in., gravel 3¾ ft.,	.009
703	Subsoil,	.0016
698	Plat No. 5, barley, soil 8 in., gravel 3¾ ft.,	.005
704	Subsoil,	.009
699	Plat No. 6, clover soil, 12 in., gravel 4½ ft.,	.01
705	Subsoil,	.024

Soils from Helena and vicinity.

Lab. No.	Description.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
425	Soil. Ft. Harrison Cantine.	.011	.056
426	Subsoil, Ft. Harrison, Mont.	.027	.080
427	Soil, Helena, Montana, 6 in. deep, sampled 100 yards west of M. C. Depot, and north of car track. Mixed with irregular limestone fragments,	.012	.062
428	Subsoil of No. 427	.068	.053
429	Soil, Ten Mile Gulch between Broadwater Hotel and State Nursery Co., Helena. Soil 3 ft. to 4 ft. deep. Gravel below. Water 2½ feet,	.230	.039

From Sappington.

Lab. No.	Description.	Percent of Sodium Sulfate.
417	Surface crust.	22.91

Henry Heeb, Gallatin county. Sampled in timothy and wild grass meadow. Unable to dig deeper than one foot. Formerly alkalied.

Lab. No.	Description.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
419	0 to 6 inches deep,	.039	.058
420	6 to 12 inches deep,	.028	.058

Henry Heeb, Gallatin county. Samples taken on highest ridge in oat field. Oats failed to grow on ridge but good yield elsewhere. Water failed to reach this ridge. Mr. Heeb believes water washes out alkali completely.

Lab. No.	Depth in Inches.	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
421	0 to 12,	1.39	.042
422	12 to 24,	.41	.078
423	24 to 36,	.13	.059
424	36 to 48, gravel, water.	.15	.053

COMPARISON WITH OTHER SOILS.

As a basis for comparison the analysis of a number of soils from humid regions is here offered. It will be noticed that while there is an almost complete absence of soluble sodium sulfate in these soils, the amount of alkalinity is in general not far from that shown to be present in average Montana alkali soils. The samples used are all from the reporters of the American Association of Official Agricultural Chemists and have been very carefully analyzed by many of the chemists of the Association. The sources of these soils with their history and analysis follow :

A. O. A. C. 1895. Sample No. 1.—From plot 5, acre P, Kentucky Experiment Station Farm; collected November 22, 1894, by taking up, with a tool made for the purpose, cylindrical cores of soil to the depth of 6 inches from 60 different places at regular intervals over the whole extent of the plot (one-tenth acre). In this way about 70 pounds of soil were obtained, and this, after thorough mixing with a spade, was sifted through a one-eighth inch mesh sieve and thoroughly air dried; it was then mixed again and stored in a box from which the samples sent out were taken. These samples were not bottled, but simply wrapped in paper. Acre P of the Kentucky Station has been planted with corn for seven years in succession previous to the taking of this sample, in an experiment with commercial fertilizers, in which each plot received the same fertilizer every year. The plot in question (No. 5) received available phosphoric acid and nitrogen at the rate of 57 and 26 pounds per acre respectively, each year, in the form of acid phosphate and nitrate of soda. The yield from this plot in 1894, calculated to the acre, was: ear corn, 1,078 pounds; fodder, 2,030 pounds.

A. O. A. C. 1895. Sample No. 2.—From plot 5 of field of the Rhode Island Experiment Station at Kingston, used for experiment with fertilizers on corn from 1890 to 1894, in which year miscellaneous crops were grown, collected by H. J. Wheeler in a manner similar to that described under Sample No. 1, but taking the soil from the south two-thirds of the plot and from about twelve places only. The soil was a sandy loam, containing much vegetable matter, giving it a dark chocolate color. The rock fragments sifted out were granitic in character. This plot had received its fertilizers each year, beginning with 1890, about 25 pounds of nitrogen and 76 pounds of potash per acre, in the form of nitrate of soda and muriate of potash.

A. O. A. C. 1895. Sample No. 3.—From acre P, plot 6, Kentucky Station; collected and prepared in the same way and at the same time as No. 1. This plot had received each year 80 pounds of potash per acre and about 26 pounds of nitrogen in the form of muriate and nitrogen. The yield from this plot in 1894, calculated to the acre, was 2,457 pounds ear corn, and 3,310 pounds fodder.

A. O. A. C. 1895. Sample No. 4.—From plot 2 of the Kingston, R. I., field; collected by H. J. Wheeler in the same way as No. 2. This plot had received each year about 50 pounds of available phosphoric acid per acre in the form of dissolved bone black.

A. O. A. C. 1896. Sample No. 1.—From acre P, plat 2, of the Kentucky Experiment Station Farm. It has been cultivated for a number of years without the addition of any fertilizer, and will not, at present, produce a large crop. From several years' tertilizer tests on adjacent plats, it has been shown that in all probability the trouble is lack of available potash.

A. O. A. C. 1896. Sample No. 2.—From the Kentucky Experiment Station Farm. The soil has not been under cultivation, at least for a number of years, and in all probability contains sufficient available potash to produce several good crops.

A. O. A. C. 1897. Sample No. 1.—From Rothamsted Experiment Farm. Wheat grown continuously for 53 years without any manure. Gilbert mark W8.

A. O. A. C. 1897. Sample No. 2.—From Rothamsted Experiment Farm. Gilbert mark B2A. Fertilized for 58 years with 200 pounds ammonium salts and 350 pounds superphosphate per annum.

	Percent of Sodium Sulfate.	Percent of Alkalinity in terms of Sodium Carbonate.
A. O. A. C. No. 1—1895	.033	.004
" No. 2—1895	.015	.009
" No. 3—1895	.018	.014
" No. 4—1895	.033	.019
" No. 1—1896	.007	.009
" No. 2—1896	.005	.014
" No. 1—1897	.054	.072
" No. 2—1897	.017	.067

PLANS.

It is our purpose to continue the work thus begun for several years. We desire to make a thorough survey of the State to fully determine the distribution of the alkali, and to continue the investigation in the field already studied, noting especially the variation of salts under the different prevailing conditions.

ACKNOWLEDGMENTS.

While it would be impossible to mention all who have in one way or another aided in the prosecution of this work, it would also be manifestly unjust not to make some note of the especial help rendered by others.

To Mr. I. D. O'Donnell who was always ready to furnish transportation, and also to assist in the taking of samples, and whose extensive information concerning conditions existing in the Billings valley was of great use to one originally unfamiliar with that section ; to Messrs. L. A. Nutting, P. B. Moss, Samuel Holmesland, Harry Ramsey, T. C. Armitage, Fred Sanford and others who furnished transportation and assisted in sampling, my especial thanks are due.

Mr. Cobleigh, assistant chemist, and Mr. Burk, laboratory assistant, whose aid in sampling soils, preparing them for analysis and in the actual analytical work were indispensable to me, deserve especial commendation, and I wish here to express my indebtedness to them.

The works of Dr. E. W. Hilgard, who may be considered the great authority on this subject, are especially commended to any who may desire to continue this study further and in other fields.

SUMMARY.

1. Almost without exception where alkali exists in Montana it is of the "white" kind and not the "black."

2. The alkali owes its origin to the rock from which the soil was formed, and is present because the annual precipitation is not sufficient to carry it away in solution.

3. There is no economical chemical antidote for "white alkali." For "black alkali" gypsum is used. This changes it into the less baleful "white alkali."

4. Where pecuniary conditions permit, the alkali lands should be underdrained.

5. Judicious surface flooding is beneficial.

6. Alfalfa is the ideal crop for alkali lands.

7. Irrigation should be practiced with caution.

8. Patience allied with intelligent farming will improve bad fields, and prevent threatening conditions becoming worse ones.

630.679
M9ab

UNIV. OF MICH.
JUN 1 190

BULLETIN NO. 19.

Montana
Agricultural
Experiment Station

......OF......

THE MONTANA COLLEGE OF AGRICULTURE.

The Sugar Beet in Montana.

BOZEMAN, MONTANA, OCTOBER, 1898.

ROCKY MOUNTAIN HUSBANDMAN,
White Sulphur Springs,
MONTANA.

Montana Agricultural
EXPERIMENT STATION.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman.
Peter Koch, Secretary and Treasurer	Bozeman.
George Kinkel, Jr., Vice-President	Manhattan
Walter Cooper	Bozeman
Nelson Story	Bozeman

EXPERIMENT STATION STAFF.

S. M. Emery,	Director and Horticulturist.
F. W. Traphagen, Ph. D., F. C. S	Chemist.
E. V. Wilcox, Ph. D	Biologist.
Robt. S. Shaw, B. S. A.	Assistant Agriculturist.

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

Montana Experiment Station,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Hist. & Miscellaneous Library 7-1-09.

MONTANA EXPERIMENT STATION.

Bulletin No. 19. **October, 1898.**

The Sugar Beet in Montana.

F. W. TRAPHAGEN.

INTRODUCTION.

For several years experiments have been in progress in Montana, the purpose of which was to determine whether our conditions of soil and climate are adapted to the production of the sugar beet. The results of these experiments are embodied in the present report.

Considered with due reference to the fact that these beets were grown, as a rule, by those who had had no previous experience in sugar beet culture, the results are excellent and certainly encourage us to continue the experiments with a constant effort toward the improvement of cultural conditions. It is a well known fact that the beet responds very quickly, more quickly, perhaps, than any other crop, to variations in climate, soil and culture, and it is through a careful observation of these conditions, with an intelligent course of procedure based upon the same, that we may expect to improve the product, which is already very good, but which the results at the Experiment Station prove are not as good as they should be.

HISTORY OF THE BEET SUGAR INDUSTRY.

Oliver de Serres, about the end of the sixteenth century, first drew attention to the similarity of boiled beet juice to sugar syrup.

Marggraf about the middle of the eighteenth century showed that beets and several other varieties of root crops contained sugar, while his pupil, Achard, about fifty years later, first made sugar in large quantity from beets, and from the beginning of this century to the present time, when the annual production of beet sugar amounts to nearly five million tons, the efforts for its economical production have been great and continuous. During the early years of the industry, the Emperor Napoleon, by his immediate interest, by gifts of money, by placing aside land for use in beet culture and by the giving of prizes and decorations, did much to further its progress.

The history of the efforts to manufacture beet sugar in our own country dates back to 1830, and from that time until within the present decade a series of failures is recorded which were due to lack of technical knowledge on the part of those in charge. To this lack of knowledge is directly chargeable the selection of sites for factories, either in one way or another, not suited for the purpose.

Not until within the last ten years has this industry established itself upon what may be considered a secure foundation, and I am sure that judged by the results of the past few campaigns of some of the successful companies, even the most skeptical must acknowledge the fact that the manufacture of beet sugar is at last firmly established in the United States.

PRODUCTION AND CONSUMPTION.

The world's production of sugar in 1895 was 8,323,943 tons, of which 57 per cent was beet sugar.

The consumption, of course, keeps pace with the production, and in 1895 amounted, in the United States, to 1,950,000 tons, which has been estimated to amount to an average of 62.6 lbs. per capita. If the consumption in Montana is proportional to the average consumption of the United States, it amounts to 12,520,000 lbs. on the basis of a population of 200,000.

If this were produced within our own State all this money could be diverted to other uses and we would be proportionally richer.

It is estimated that the annual import of sugar into the United States is something like 1,800,000 tons, which is valued at more than $100,000,000.00. It is generally conceded that this could be produced in this country at a profit. This being true. note what opportunities are offered for the further development of the beet sugar industry.

The following, quoted from Iowa Bulletin No. 37, applies also to Montana :

"The people of Iowa annually pay out about $6,000,000 for sugar. Perhaps it does not often occur to us that this expenditure amounts to about $16,000 a day, by the people of an agricultural state, for a product that is purely agricultural in its primary form, and for the production of which all other conditions are favorable. An acre of good Iowa land planted to corn and yielding forty bushels, and marketed at twenty cents per bushel, will buy about 150 pounds of pure granulated sugar. The same area planted to good sugar beets and properly cultivated will easily yield 2,500 to 3,000 pounds of pure sugar. There is, of course, a large outlay and expenditure in growing the beets, and the expense of manufacturing is also involved in the production of the sugar, but the cash return from an acre of corn on the foregoing basis is only $8, while the cash return to the farmer from a good crop of sugar beets is $45 to $50 per acre. (It should be noted in this connection that all this money is spent for labor on the farm.) Within a comparatively few years, sugar has assumed a prominent place in the daily bill of fare in all civilized nations; and it is no longer regarded as a mere luxury in the form of a condiment or sweetening for other foods, but recent investigations in testing the endurance of the European army on various foods have developed the fact that sugar is an important nutriment and well calculated to * * * * * * sustain physical and mental exertion. It is not strange, then, that the consumption of sugar by the American people should have reached over sixty pounds per capita annually within a few years, and the world's consumption of sugar increased over two-thirds within a decade. We consume over twice as much sugar per capita as the German people, notwithstanding the fact that Germany leads all the nations in its production of sugar for export. So important is this industry regarded there, that a tax is put on the sugar consumed at home and a bounty paid on that exported. It would require not less than fifteen or twenty well equipped, fully organized factories, of from three to five hundred tons daily capacity, running day and night during the ordinary manufacturing season, to produce the sugar consumed by Iowa alone. These considerations, together with the fact that Iowa lies almost wholly within the sugar belt as described by the lines of favorable climatic and soil conditions for sugar production, have led to the extensive investigation of this subject that is now being carried on in various parts of the state. There are good and essential reasons why the beet sugar industry should be established in Iowa. In addition to saving the expenditure of $6,000,000 annually that should be kept at home, it would bring a better system of agriculture to the State in all of its branches. Sugar beet culture would bring more thoroughness, more careful methods, more intelligence and a more rational and balanced system of farming. Every well cultivated field of sugar beets stands as an object lesson in good farming and a protest against superficial and slovenly methods. Sugar beet growing necessitates the intensive system of agriculture, and this system applied to Iowa means better crops, better stock, better farm products, better homes and a better farm life in every way. The introduction of beet culture would be of incalculable value to the live stock industry, independent of its other advantages. The beet pulp and the roots that would be fed directly to the stock would result in higher excellence and greater economy of production. Then, too, there is no crop that could be so advantageously introduced in our plan of rotation as the sugar beet. It is eminently adapted to combining with the green crops. Chemically considered, pure sugar consists of nothing but carbon dioxide and water, both of which nature has supplied in great abundance. The removal of a crop of sugar takes nothing from the soil that is of any value in fertility. If the pulp is fed and the droppings of the animals applied as manure, beets will exhaust our lands less than any crop we grow. There are only three agricultural products that can be grown extensively without exhausting the soil, viz.: sugar, cotton and butter. When we sell butter we sell pure fat, and $1,000 worth of it would not contain $1 worth of material that has any fertilizing value, and if we were to sell sugar we would be selling pure carbohydrates that would have no value as a fertilizer; but $1,000 worth of wheat or oats at present prices would take from the land over $300 worth of fertility, or at least that which would cost that amount if restored in the form of commercial fertilizers. Commercial fertilizers will never become necessary in Iowa, provided rational policies are pursued, but it will be profitable to conserve fertility by every reasonable and judicious method."

For the following tables of statistics upon the Average Consumption af Sugar per capita, the World's Consumpticn of Sugar, the Beet Root Sugar Crops of Europe, and the Cane Sugar Crops of the World, I am indebted to John Hyde, Statistician of the United States Department of Agriculture:

TABLE No. 1.

AVERAGE CONSUMPTION OF SUGAR PER CAPITA AS COMPARED WITH THE POPULATION OF 1885.

COUNTRIES	1892	1893	1894	1895	Population. 1895
	POUNDS				
Germany	23.56	22.90	26.71	26.78	51,650,000
Austria Hungary	16.05	17.20	16.57	19.81	43,456,000
France	30.46	27.86	27.80	30.61	38,800,000
Russia	10.34	10.94	11.06	10.94	100,234,000
Netherlands	26.88	22.90	25.55	31.30	4,732,000
Belgium	21.29	21.09	21.73	22.50	6,325,000
Denmark	43.63	43.53	42.96	45.41	2,300,000
Sweden-Norway	24.14	23.64	24.82	24.95	6,873,000
Italy	7.18	7.00	7.07	6.65	30,724,000
Roumania	3.90	4.53	4.07	4.03	5,800,000
Spain	11.06	12.38	12.47	13.68	17,650,006
Portugal	12.43	12.51	13.09	12.92	5,082,000
Great Britain	80.73	77.40	84.78	86.09	38,927,000
Bulgaria	5.16	6.07	7.14	8.88	3,310,000
Greece	8.62	7.38	7.29	6.26	2,235,000
Servia	3.81	4.22	4.25	4.01	2,256;000
Turkey	9.30	7.64	7.25	7.65	21,983,000
Switzerland	31.30	31.62	42.30	44.66	2,895,009
Total Europe	22.64	22.02	23.25	25.64	385,177,000
United States	63.76	68.83	66.64	62.60	69,753,000
Total	29.00	28.20	29.83	31.07	454,930,000

TABLE No. 2.

THE WORLD'S CONSUMPTION OF SUGAR.

Years	United Kingdom Tons	United States Tons	Other Countries Tons	Total Tons
1893	1,353,000	1,907,000	3,099,000	6,359,000
1894	1,386,000	2,013,000	3,879,000	7,278,000
1895	1,539,000	1,950,000	4,433,000	7,922,000
1896	1,503,000	2,100,000	3,287,000	6,890,000
1897	1,500,000	2,100,000	3,874,000	7,474,000

Table No. 3—Beet Root Sugar Crops of Europe.

Country	1898	1897	1896	1895
	Tons	Tons	Tons	Tons
Germany	1,850,000	1,836,536	1,615,111	1,844,586
Austria	835,000	984,007	791,405	1,055,821
France	820,000	752,081	667,858	792,511
Russia	735,000	714,936	712,096	615,058
Belgium	225,000	288,009	235,796	243,957
Holland	125,000	174,206	106,829	84,597
Other countries	188,000	202,990	136,340	156,000
	4,778,000	4,902,765	4,285,429	4,792,530

Table No. 4—Cane Sugar Crops of the World.

COUNTRIES	1898	1897	1896	1895
United States—Cane	280,000	282,009	237,720	317,306
Beet	41,347	40,000	30,000	20,443
Porto Rico	54,000	54,000	50,000	52,500
Canada (Beets)	300	300	500	300
Cuba	320,000	210,500	240,000	1,040,000
British West Indies—Trinidad	55,000	55,000	58,000	56,641
Barbados	52,000	58,249	47,800	32,343
Jamaica	30,000	30,000	30,000	30,000
Antigua and St. Kitts	25,000	29,000	24,000	20,000
French West Indies—Martinique	35,000	35,000	35,000	29,000
Gaudeloupe	45,000	45,000	45,000	43,000
Danish West Indies—St. Croix	13,000	13,058	8,000	7,000
Haita and San Domingo	48,000	48,800	50,000	38,000
Lesser Antilles, not mentioned above	8,000	8,000	8,000	8,000
Mexico	2,000	2,000	2,000	2,000
Central America—San Salvador	500	500	500	500
Nicaragua	500	500	500	500
British Honduras (Belize)	200	200	200	200
South America—Br. Guiana (Demerara)	98,000	90,789	105,000	95,919
Dutch Guiana (Surinam)	6,000	6,000	6,000	6,000
French Guiana	....	....	....	....
Venezuela	....	....	....	....
Peru	70,000	70,000	68,000	68,000
Argentine Republic	110,000	165,000	130,000	90,000
Brazil	195,000	210,000	225,000	275,000
Total in America	1,488,847	1,471,005	1,401,220	2,232,652
Asia—British India	50,000	50,000	50,000	50,000
Siam	7,000	7,000	7,000	7,000
Java	541,581	473,420	605,025	486,051
Japan (cons'n 125,000 tons, mostly imported)	....	....	....	....
Philippine Islands	160,000	190,000	240,000	180,000
Cochin China	30,000	30,000	30,000	30,000
Total in Asia	788,581	750,420	932,025	753,051
Australia and Polynesia—Queensland	65,000	70,000	60,000	91,712
New South Wales	30,000	30,000	30,000	35,000
Hawaii Islands	225,000	224,220	201,632	131,698
Fiji Islands	30,000	30,000	30,000	27,000
Total in Australia and Polynesia	350,000	354,220	321,632	285,410
Africa—Egypt	80,000	95,000	92,000	90,000
Mauritius and other British Possessions	120,000	150,000	140,000	115,000
Reunion and other French Possessions	45,000	48,000	44,700	35,300
Total in Africa	245,000	293,000	276,700	240,300
Europe—Spain	20,000	20,000	20,000	20,000
Total cane sugar production	2,892,428	2,889,545	2,951,577	3,531,413

TABLE No. 5.

STATISTICS OF THE PRODUCTION OF BEET SUGAR IN THE UNITED STATES FOR THE YEAR 1897.

(From Special Report on the Beet Sugar Industry, U. S. Dept. Agric. 1897.)

Number of factories in operation	9
Number of acres of beets harvested	41,272
Approximate average price paid for beets	$4.10
Approximate average per cent. of sugar in the beets	14.49
Total pounds of granulated sugar made	90,060,470
Total pounds of raw sugar made	481,200
Granulated sugar obtained per cent beets	11.56
Raw sugar obtained per cent. beets	0.06
Total sugar obtained per ton (2,000 pounds) of beets, pounds	232.4

TABLE No. 6.

STATISTICS OF INDIVIDUAL FACTORIES FOR THE YEAR 1897.

NAME OF FACTORY AND LOCATION	Beets harvested—Acres	Beets harvested—Tons	Price paid per ton	Time the machinery was in operation—Days	Sugar content of the beet Per cent	Total output of Granulated Sugar—Pounds
Alameda Sugar Co Alvarado, Cal	4,808	48 773	$4.00	90	14 20	10,198,648
Chino Valley Beet Sugar Co., Chino, Cal	9,678	97,197	(a)	151	15 10	24,303,122
First N. Y. Beet Sugar Co, Rome, N. Y	700	4,325	$5 00	45	(b)	765,700
Oxnard Beet Sugar Co. Grand Island, Neb	4,282	38,607	(d)	(d)	12 90	6,798,300
Los Alamitos Sugar Co. Los Alamitos, Cal	2,800	29,547	$4.16	105	15.73	6,017,900
Norfolk Beet Sugar Co. Norfolk, Neb	4,029	36,113	(d)	(d)	13.60	7,941,400
Pecos Valley Beet Sugar Co., Eddy, N. Mexico	1,600	5,700	$4.00	38	14 00	1,020,000
Utah Beet Sugar Co. Lehi, Utah	3,000	18,500	$4.25	56	13.20	3,670,600
Western Beet Sugar Co. Watsonville, Cal	10,375	110.878	$4.00	104	15.00	29.776,000
Total	41,272	389,635				90,491,670

(a) $3.50 per ton for 12 per cent. beets, and 25 cents per ton for each per cent. above 12. The Chino Factory employed a saccharate process.

(b) Red beets 5½ to 12 per cent. sugar; white beets 13 to 17 per cent sugar. Average analysis not reported.

(c) 431.200 pounds raw sugar are included.

(d) Not reported.

CLIMATE.

After a study of the climatic conditions favorable to the successful culture of the beet, a mean temperature of 70 degrees Fahr. for the three summer months was considered to be very important, and a sugar beet map was drawn showing this isothermal line. We are far north of it, although in the Yellowstone valley there is a locality where the mean temperature is 71 degrees Fahr.

Where irrigation is used the question of the extent of rainfall is not of great importance. Where irrigation is not practiced the rainfall for the months from April to October inclusive should amount to about twenty inches.

"Irrigation land has a great many advantages over land depending on the caprice of nature for its water supply. Sugar beets require a large and continuous supply of water during the early part of the growing season, while abundant rains in the autumn lower the sugar content very materially. Many instances have occurred where crops were severely injured by late rains, and the newspapers report that one of the largest sugar factories in the West will remain idle this season on account of drought. Sugar beets are injured by too warm weather, but require an abundance of sunshine, of which in this country there is no lack. One disadvantage of the climate of Wyoming is the shortness of the season, on account of which beets do not always have time to fully mature, and crops cannot be put in at different times so as to secure succession of ripe beets at the factory while in operation. It would probably be necessary to put most of the beets in silos."—(Wyoming Bulletin No. 36, P. 196).

Though the conditions existiug in Montana are not the *ideal theoretical* conditions, yet we can grow, as has been demonstrated, good crops of beets with high sugar content. The average of results in Montana compares favorably with any state's product.

It must not be understood that those who have studied the sugar beet in the United States have laid down any hard and fast rules concerning its distribution. They have attempted to formulate rules that may serve as guides, but in every case they grant that there may be many localities in which conditions are not just what they have stated as desirable, where sugar beets may be successfully grown.

"There is probably not a state or territory in the Union which is not capable of growing a fair article of sugar beets. Even in the far South beets of fair sugar content have been produced, and with good tonnage; but when the competition of the world is to be met, with the price of sugar as low as it is now, only those parts of the country where the soil and climate are especially favorable can be expected to compete successfully with the beet sugar industry already firmly established in older countries. The sole valuable lesson, therefore, of the promiscuous distribution of beet seed is in the fact that, as a rule, those regions best suited to the growth of the sugar beet will gradually be outlined, and intending investors led to the proper localities for the establishment of factories."

"In so far as thermal conditions are concerned, vast areas of the arid regions could be devoted to beet culture if the other conditions of culture were favorable. The differences of elevation of the plateaus cause numerous sudden changes of temperature, so that there are doubtless many localities not marked on the map where the mean summer temperature is almost identical with that which has already been mapped out. By reason of the meagerness of data, experimental and otherwise, relating to this whole region west of the Missouri river, the shading showing the probable extension of the beet area beyond the borders of the basic thermal belt has been omitted. The general discussion of this thermal belt, accompanied as it is by the chart of precipitation, is not necessary at this point."

"On the other hand, there are many localities lying outside the indicated belt, both north and south, where doubtless the sugar beet will be found to thrive. The map, therefore, must be taken to indicate only in a general way those localities at or near which we should expect success to attend the growth of sugar beets in the most favorable conditions other than temperature alone."

"There is another class of influences that modify the sugar beet belt. Take, for instance, altitude. There may be an extent of territory sufficient to support a beet sugar factory where, on account of its altitude, the conditions are quite different from those prevailing in the surrounding country, and we have no doubt that there are a great many localities of this kind. It should be the aim of the people of these high localities, if they are interested in this industry, to test their conditions separately and apart from the experiments in other portions of the state. The trend of mountains and location of valleys modify materially the season in localities."

"It is also quite true that the agricultural surveys which will be conducted by the several states will locate definitely, beyond the limits already outlined, the areas where successful beet culture will be practiced. I may venture the prediction, however, that these areas will be contiguous to the zone which is already mapped out, and that the future beet sugar industry of the United States, when it shall have reached a magnitude sufficient to supply to our people a large part of the sugar they consume, will be located almost entirely within the areas which have been thus traced."

"In connection with the temperature must be considered the rainfall, the contour and the nature of the soil, the possibility of irrigation, the abundance of subsoil mixture, the proximity of coal, limestone and water, price of labor, facilities for distribution and transportation, and many other matters which are important in a discussion of the subject. It is further evident that the tracing of a single isothermal line and the arbitrary addition thereto of a certain width of land on either side do not give even the proper theoretical thermal basis for a careful study of climatic conditions."—(Special Report on the Beet Sugar Industry, 1897).

"The results obtained at the Montana Experiment Station show what can be done by careful culture, and indicate that Montana, under proper conditions, is capable of producing a fairly good sugar beet. The data in general are sufficiently encouraging to warrant the Agricultural Experiment Station of the state in making a more thorough and careful agricultural survey of the possibilities of beet production." —(H. W. Wiley, Report on Beet Sugar Industry, 1897).

This it seems to me is a sufficient statement of the case. The fact remains that we have succeeded in growing sugar beets in which yield, sugar content and purity are up to standard, which is usually put in this country at 12 per cent. sugar in the beet with a purity coefficient of 80. No one denies facts, and no one has pretended to authoritatively state that conditions existing in Montana would make it impossible to do this. All of the data of analytical work of the Chemical Division of the Department of Agriculture supports the results of this Station, and these analyses extend over many years.

Late in January of the present year two samples of crude products were received from Mr. B. C. White, Superintendent of the Reform School at Miles City.

"No. 1" was a dark colored syrup containing forty-four per cent. of sugar; this was part of the thirty-three ounces of syrup made from the juice of eleven pounds of sugar beets.

"No. 2" was a lump of dark brown sugar, not very unlike taffy candy, which contained fifty-six per cent. sugar. By way of comparison it may be stated that the brown sugar of commerce contains little more than eighty per cent. sugar.

This product of inexperienced sugar-makers, without proper equipment for the work and with no means for the purification of the sugar, is an earnest appeal to what might be done under better conditions. Mr. White deserves much credit for his work which, so far as we know, is the pioneer effort toward sugar manufacture in the state.

SOILS.

In order that a soil may be suitable for the sugar beet it must be easily penetrated by the descending root. A sandy or loamy soil with the subsoil either deep or equally readily penetrable by the beet, is required, for otherwise misshapen beets with disproportionately large crowns result.

This precludes the presence of clayey subsoils or stiff hard-pans near the surface and makes it difficult, if not impossible, to grow beets in a clay soil. The wonderful results attending the planting of root crops in so many parts of Montana shows how well its soil is adapted to such plants.

The following table gives the average composition of the soil of the Experiment Farm where excellent results have been obtained:

TABLE No. 7.

AVERAGE OF SOIL OF EXPERIMENT FARM.

Coarse Material	1.664 per cent.
Fine Earth	98.336 "

ANALYSIS OF THE FINE EARTH :

Insoluble Matter	80.410	"
Soluble Matter	19.590	"
Soluble Silica	.130	"
Potash	.600	"
Soda	.360	"
Lime	1.160	"
Magnesia	1.150	"
Manganese Oxide	.960	"
Peroxide of Iron	3.920	"
Alumina	6.150	"
Phosphoric Acid	.290	"
Sulphuric Acid	.113	"
Organic Matter	5.440	"
Moisture	4.080	"
Nitrogen	.170	"

CULTIVATION.

Deep plowing, thorough pulverization and frequent loosening of the soil are essentials to satisfactory results. The previous fall the ground should have been subsoiled to a depth of from 12 to 15 inches, and in the spring, before seeding, the soil should be well broken up. For best results the soil must be readily penetrated by the root to a depth of more than twelve inches, for a well-formed, good-sized beet will be that long.

It is further necessary to have the soil loose to prevent any considerable growth of the root above ground, for all that portion known as the crown is removed before the beets are weighed at the factory; and where soil is not loose the crowns develop to a great extent. Do not cultivate too deep between the rows, especially when the plant is nearing maturity. Cultivate as soon as possible after irrigation, but avoid trampling the ground while wet.

Irrigate by furrows. Do not flood the beets. Thin out the plants when they reach the four-leaf stage.

Leave spaces of from six to ten inches between plants and have rows at least eighteen inches apart.

The details of manipulation together with a description of the tools used, is to be found in Farmers'. Bulletin No. 52, which may be obtained by applying to the Secretary of Agriculture, Washington, D. C. This bulletin is a very excellent review of the question, and every mer who is interested in the sugar beet should have a copy. Much that is important concerning climate, soil, cultivation, harvesting, etc., is left out of this report because of the very thorough discussion given by Dr. Wiley in the above-numbered bulletin. An inspection of the reports of the Montana farmers will show that they have not given the crop the attention that it requires.

STORAGE.

As cold weather comes in Montana before the manufacturer's campaign could be ended, the question of storage and protection from cold becomes important. Samples of beets stored by us showed late in January sugar contents of 18.53, 17.48 and 15.58 per cent. with coefficients of purity of 90.2, 85.6 and 84.1 per cent. respectively.

The samples showed no appreciable amount of drying and would indicate that the loss due to storage over several months would be slight. When the time beets are stored extends to five or six months there is found to be an increase in weight and a loss in sugar, because of vital processes in the plant.

COST OF CROP.

It is hard to form an estimate of the cost of the various operations incident to raising a crop of sugar beets when the work is done on an experimental scale. For this reason, therefore, I introduce here a portion of a letter from Mr. C. A. Granger, of the Utah Sugar Co., to Prof. H. H. Nicholson, in which are set forth the costs of the various operations in Utah :

"In replying to your letter as to the cost to the Utah farmers of cultivating and harvesting their sugar beets, I would respectfully submit the following :

Fall plowing, 12 inches deep	$	3 00
Pulverizing in the spring		1.00
Rolling		.30
Planting		.40
Seed, 12 lbs. 18 cts		2.16
Hoeing and thinning, first time		8.50
Hoeing, second time		3.00
Furrowing out for irrigating, two times at 75c		1.50
Irrigating twice at 50c		1 00
Cultivating after irrigating, two times at 75c		1.50
Plowing beets out		1.50
Pulling beets out after plow		3.00
Topping 12 tons, at 45c		5.40
Hauling 12 tons, at 60c		7.20
Total expense	$	39.46
Yield, 12 tons per acre at $5		60.00
Net profit per acre	$	20.54

The above figures are susceptible to some slight changes, depending upon varying conditions, but in the aggregate they are just as exact as they could be arrived at, having been obtained directly from the farmers as the result of their last year's experience. They allow for $1.50 to be paid for a day's labor, and are based upon the rows of beets being eighteen to twenty-four inches apart and the beets thinned to six and ten inches in the rows.

The yield of twelve tons to the acre, which is here used, I consider as being too low for an average by at least three to four tons, for there were individual acres last season which produced over thirty tons each, and it can safely be estimated that with the advantages of irrigation, the average in the future will be not less than from fifteen to twenty-five tons.

In Nebraska the cost is placed below this—at $32.21 per acre.

The following figures will show the cost to Montana growers when operating on the experimental scale. There is little doubt that these figures could be greatly reduced if the operations were carried on with large acreages.

Bitter Root Stock Farm, Hamilton, Montana. Estimated cost of growing one-half acre:

Plowing	$	1.20
Disc		.80
Harrowing		.50
Smoothing		.50
Planting		.70
Thinning and first cultivation		6.00
Cultivating four times		1.60
Irrigating four times		1.50
Digging		6.20
Total	$	19.00

Product per acre, 32 tons.

Henry Buckhouse, Missoula, Mont. Cost of experimental one-half acre:

Preparing 2 days with team	$	6.00
Planting one-half day		1.00
Thinning 4 days		8.00
Cultivating one day		3.00
One irrigation		3.00
Digging 2 days		6.00
Total	$	27.00

D. R. Thornber, Chinook, Mont. Cost of raising one acre of sugar beets:

Preparation of the soil	$ 5 00
Planting	5 00
Thinning	10.00
Cultivation	4.00
Irrigation	2 00
Digging	20.00
Total	$ 46.00

Yield 19 tons.

I. D. O'Donnell, Billings, Mont. Cost of raising one-half acre of sugar beets:

Plowing, harrowing and marking, man and team	$ 1.50
Sowing seed	.75
First cultivation	.75
Second cultivation	.75
Thinning	2.00
Irrigating	.75
Digging and hauling to root house	4.50
Total	$ 11.00

Yield 18 tons.

J. W. Strevell, Miles City, Mont.

The following letter from Judge Strevell, of Miles City, is so full of important facts that it is quoted in full:

"I rounded up my man last night and we did the best we could to make out the statement for you in regard to the beets.

1. The ground upon which the beets were planted was sod, broken in the fall of 1897; then in the spring I put the disc harrow on it, first cut the sod up and plowed it again to a depth of twelve inches, then on the acre I sowed about twenty loads of rotten fertilizer, using old manure, then put the harrow on it and pulverized it thoroughly so that it planted very nicely. This left the ground in very good shape but entirely new, never having had a crop on it since the foundation of the world.

2. I put the cost of preparing the acre, independent of manure, at $7.00.

3. Planting beets, $4.00.

4. Cost of thinning the beets, $8.00.

5. Cost of cultivating beets, $4.50 (two cultivations.)

6. To digging beets and putting in root house—two men five days at $2.00—$20.00.

7. Irrigating beets, $4.00.

The beets were planted on the 7th day of May, as my man remembers the time, and I think this is correct. They were irrigated twice, once in July and once in August.

Now, unfortunately, as to the yield per acre, we have slipped a cog on this. My man had a record of it, he says. The record supposedly was done with—he burned it up. All I can say in this regard is, that you probably never saw a heavier yield. By this I do not mean that you have not seen larger beets. The beets were of a very uniform size and stood as thick as they ought to stand—if anything a little too thick—but the peculiarity of it was the uniformity of size, and I never saw a handsomer crop grow anywhere, so that you may put this yield as high as any that you have ever received from anywhere. This I believe to be absolutely true.

My great regret is that we lost the account of the yield. We took the mode that you recommend for that purpose, counting the beets within a given space, then taking the whole length of the row and then the number of rows determined by the weight of the beets.

The real truth about it is that while I believe I raised as fine a crop of beets as ever were raised anywhere, yet I am called away from home so much and my business is not primarily farming, that I am not the best kind of hand to do these things and keep the record of them in detail.

I had a farmer with me from Michigan who was an expert at this sort of business and he never got done standing looking at the field and making exclamations about it. He said he had never seen equal weight of anything growing on an equal quantity of ground."

SUGAR BEETS AS CATTLE FOOD.

"Thousands of farmers in various parts of the country are growing beets in an experimental way and have no opportunity to dispose of their product to sugar factories. These farmers may, nevertheless, find the growing of small quantities of sugar beets profitable by using the product for cattle food. Following is an analysis lately made in this laboratory of a sample of sugar beets received from a locality such as is mentioned above :

COMPOSITION OF FRESH BEET PULP.

	Fresh Pulp.		Dry Matter.	
Moisture	73.87	per cent.	.....	per cent.
Fiber (crude)	1.53	"	5.89	"
Ash	1.35	"	5.18	"
Ether extract (fat)	.11	"	.42	"
Proteids	2.21	"	8.47	"
Sugar and other carbohydrates	20.93	"	80.04	"
	100.00		100.00	

The sample in question contained 73.87 per cent. of water and 26.13 per cent. of dry matter. The analyses of hundreds of samples of beets in this laboratory show the average content of fiber, usually called "marc," is about 5 per cent. In the process of analysis all this marc is dissolved except that which is entered above as crude fiber, namely, 1.53 per cent. The difference between this and the 5 per cent. average content of marc, namely, 3.47 per cent, shows the quantity of carbohydrate matter not sugar contained in the 20.93 per cent. of total sugars and carbohydrates. The quantity of sugar in the sample analyzed was, therefore, 17.46 per cent. Practically all, however, of the carbohydrates, except those represented by the crude fiber, are digestible, so that the soluble marc has practically the same food value as the sugar itself. The ratio of the proteid matter to the digestible carbohydrates plus fat multiplied by 2¼ is 9.59. This ratio shows that the food is particularly a fattening one, and could be used to great advantage in preparing fat stock for market. The analysis also indicates that the food, to secure the best results for all round sustenance, should be fed with some highly nitrogenous ration in order to secure a smaller ratio between the two groups of nutrients. It may be said with perfect confidence that it will be far more profitable for the farmer to grow sugar beets at 12 tons per acre for cattle food than other root crops, such as turnips and rutabagas, which will yield double that quantity per acre. The food value of these crops does not depend upon the gross tonnage, but upon the actual nutrients which they contain. Sugar beets contain, as is seen, over 20 per cent. of their weight of actual nutrients, while turnips and radishes may contain only from 6 to 12 per cent."

USE OF BEET PULP FOR CATTLE FOOD.

"The residue from beet factories, in the form of beet pulp, is also a valuable food. In this country no carefully controlled feeding experiments have been conducted with this material, but the question has been studied most thoroughly in Europe, and the data obtained can be used for our guidance. There is practically no difference in chemical composition between the beet pulps obtained in Europe and in this country, so that the deductions to be drawn from the feeding experiments in that country can be applied with perfect safety to similar work here. At many of the factories in this country practical feeding tests have been made and with favorable results."—(Wiley, Special Report 1897).

DRAFT OF BEET CROPS UPON THE SOIL.

While the question of exhaustion of the soil has not as yet appealed directly to the Montana farmer, it is a question, the seriousness of which sooner or later must be met.

Experiments in California showed that twenty times as much potash, three times as much phosphoric acid and twice as much nitrogen were taken from the soil by a beet crop, as would be removed by a wheat crop.

If the pulp and tops be fed upon the farm most of this would be returned, for no mineral matter is removed by the sugar.

The pulp, after extraction of the sugar is sold by the factory for a nominal price.

SUGAR BEETS AND ALKALI.

Of the alkali salts the chloride of sodium, common salt, is the one, the presence of which in the soil, most seriously affects the quality of the beet. When sodium sulfate, which is the principal constituent of Montana alkali, is present to the extent of nearly two-tenths per cent. in the soil, it does not seem to injure the beet, for in California sugar beets containing $12\frac{43}{100}$ per cent. of sugar and having a purity coefficient of 83.98 per cent. were grown in soil containing .182 per cent. of sulfate.

The following table, however, shows that excessive amounts of sulfates affect both the sugar content and the purity :

TABLE No. 8.

Sugar beets grown on Charles Gardner's ranche near Billings.

Sodium Sulfate in 1st foot of soil	0 06	per cent.
Sodium Sulfate in 2nd foot of soil	0.98	"
Sodium Sulfate in 3rd foot of soil	0 61	"
Average weight of beets grown	26	ounces.
Average per cent. of sugar in beets	9.34	"
Average per cent. of purity	64 8	"

These beets, it will be seen, are too low in sugar and purity to serve for manufacturing purposes.

Evidently somewhere between .2 per cent., or perhaps a little less, and the above average of .55 per cent. for the three feet in the Gardner ranch, must lie the extreme limit of sulfate which may be present in a soil yielding merchantable sugar beets, and it is probable that the figures are not far from the lower number.

THE RESULTS OF ANALYSIS.

The following are tables showing the analysis of Montana grown sugar beets. These analyses were made in the Chemical laboratory of the Experiment Station and give all the information necessary for an estimate of their value for sugar making. A discussion following the tables explains the meaning of the terms used, and calls attention to some of the principal features included in the results.

TABLE No. 9.—TEST OF 1895—STATION FARM.

	Per cent. Sugar in Beet.
Klein Wanzleben	14.159
Vilmorin's Imperial	14.040

TABLE No. 10.
EXPERIMENT STATION CROP OF 1896.

Lab. No.	Date of Digging.	Average Weight.	Per cent. Sugar in Beets.	Average Weight.	Per cent. Sugar in Beets.	Average Weight.	Per cent. Sugar in Beets.
257	Sept. 18	26 oz.	15 00	14 oz.	19.20	6 oz.	15.20
258	Sept. 21	29 oz.	15.20	13 oz.	14.60	5 oz.	17.00
259	Sept. 27	19 oz.	14.40	16 oz.	16 40	9 oz.	16.00
260	Oct. 4	44 oz.	17.00	29 oz.	15 20	15 oz.	16.60
261	Oct. 11	28 oz.	15.00	16 oz.	15.80	12 oz.	14.00
262	Oct. 14	30 oz.	17 40	25 oz.	15.00	7 oz.	18.60
263	Oct. 23	24 oz.	18.00				
264	Oct. 24	23 oz.	15.00				
265	Oct. 26	12 oz.	16.00				
266	Oct. 27	33 oz.	17.00				
267	Oct. 28	18 oz.	16.00				
268	Oct. 29	18 oz.	16 40				
269	Oct 30	26 oz.	14 60				
270	Nov. 1	? oz.	15.80				

TABLE No. 11.

EXPERIMENT STATION—VARIETY TESTS—1896.

Lab. No.	Variety.	Average Weight.	Per Cent. Sugar in Beet.
271	Vilmorin's Richest	20 oz.	18 80
272	Klein Wanzleben	18 oz.	17.00
273	Klein Wanzleben	16 oz.	13.80
274	Knauer's Imperial	22 oz.	11.00
275	Klein Wanzleben	16 oz.	16.00
276	Knauer's Imperial	25 oz.	14.80
277	Knauer's Imperial	25 oz.	13.40
278	Extragreicher No. 2	82 oz.	12.60
279	Vilmorin's Richest	18 oz.	15.60
280	Zuckereicher	44 oz.	12 80
281	Vilmorin's Richest	15 oz.	16.40

TABLE No. 12.

CO-OPERATIVE TESTS—SEASON OF 1896.

Lab. No.	Name of Farmer and Location of Farm	Ave. Wt. Beet, Large—ozs.....	Per cent. Sugar in Beet	Ave. Weight Medium—ozs...	Percent. Sugar in Beet.........	Ave. Weight, Small--ozs....	Percent. Sugar in Beets.... ..	Date Analyzed.
234	C. C. Willis, Horse Plains..	53	13.00	35	14.00	14⅓	17.40	Oct. 13, '96
235	Oliver Scow, Manhattan....	74	9.40	28	14.80	6	18.40	Oct. 13, '96
236	A. Truman, Spring Hill....	35	13.00	21	13.40	7	14.00	Oct. 13, '96
237	Nelson Lundwall, Bozeman	31	13 80	15	15.20	4	15.20	Oct. 13, '96
238	G. L. Gordon, Willow Creek	78	12.00	25	12.00	15	12.00	Oct. 13, '96
239	C. L Tilden, Park City.....	58	15 80	37	16.60	24	17.00	Oct 29, '96
240	Taylor Trent, Bozeman.....	38	14.00	26	14.00	14	14 80	Oct. 29, '96
241	L. M. Jones, Meyersburg...	42	13 40	28	15.20	15	14.40	Oct. 29, '96
242	H. L Slater, Central Park	76	13.40	32	12 80	21	15.20	Oct. 30, '96
243	Sam Bell, Central Park.....	32	12.00	17	16 00	5	17.00	Oct. 30, '66
244	W. F. Rose, Duncan	..	....	12	14 60	5	14 60	Oct. 30, '96
245	G C. Monroe, Spring Hill..	..	.....	18	16.80	8	18.80	Nov. 2, '96
246	*Wm. Blain, Bozeman......	..	.....	11	4.80	6	5.00	Nov. 2, '96
247	A. L. Corbly, Spring Hill...	38	15 00	20	13 80	8	15.00	Nov. 2, '96
248	John Harper, Bozeman.....	41	11.00	20	11.20	9	12 00	Nov 2, '96
249	E. J. Thornberg, Logan....	39	12.00	20	12.00	8	16.00	Nov. 2, '96
250	Manhattan Malt. Co. Manhn	92	11 60	43	14 00	...	.....	Nov. 4, '96
251	Geo. W Spring, Bozeman..	72	16.60	31	15.00	12	17.80	Nov. 4, '96
252	Manhattan Malt. Co Manhn	..	11.60	36	13.40	....	.....	....
253	B. M. Dawes, Bozeman	..	9.20	..	13 60	....	19.00	Nov. 4, '96
254	C. W. Reynolds, Bozeman .	..	17.00	..	16 15	....	19.00	Nov. 4, '96
255	J M Robinson, Bozeman..	..	15.58	..	17.48	...	18.53	Nov. 4, '96
256	Manhattan Malt. Co. Manhn	..	8.40	..	14.00	....	.....	....

* These samples were common red beets, and not sugar beets.

Lab. No.

234—C. C. Willis, Horse Plains, Missoula County. Seed sown May 11, 1896; appeared above ground eleven days after sowing, soil sandy, not manured, irrigated last of June; irrigated once; carrots and cabbage grown on land previous year; plowed 6 inches deep; thinned June 30th; cultivated twice; hoed once; dug Sept. 30th, 1896; yield small beets 284 lbs.; medium beets 339 lbs.; large beets 149 lbs.; total 772 lbs: this yield from 2 rows 322 feet long.

235—Oliver Soow, Manhattan, Gallatin County. Seed sown May 12, 1896; plants appeared above ground 12 days after sowing; soil sandy loam, 8 to 12 inches to gravel: irrigated twice, June 1st and August 1st; used furrow system of irrigating, part got flooded and did not do well; land not used in 1895; depth of plowing 6 to 8 inches; thinned June 24th, 1896; not cultivated; hoed once, July 10th, 1896; given fair culture; weeded twice; could not give expense of production per square rod; dug Oct. 5th, 1896; yield, had no means of weighing, but by measure 17 heaping 5 gallons coal oil canfuls; 6 rows 60 feet long.

236—A. Truman, Spring Hill, Gallatin County. Seed sown May, 1896; did not remember number of days before plants appeared above ground; soil black with but little sand in it; two feet to sub-soil of clay; irrigated three times; used sprinkler system of irrigation; cabbage grown on same land previous year; depth of plowing 8 inches; cultivated three times hoed three times; have given fairly good culture: dug Oct. 9th, 1896; yield 209 lbs. on 306 square feet.

237—Nelson Lundwall, Bozeman, Gallatin County. Seed sown May 19th, 1896; plants appeared above ground ten days after sowing; soil brown clay loam about 5 feet deep, underlaid by gravel; irrigated twice used furrow system of irrigating; potatoes grew on same land previous year; depth of plowing 8 inches; thinned on June 22nd; cultivated three times with wheel hoe, on June 5th, June 23d and July 6th; gave beets fairly good culture by machine; total cost of production per square rod about 30 cents; dug Oct. 5th, 1896; yield 202⅔ lbs. per square rod.

238—Geo. L Gordon, Willow Creek, Gallatin County. Seed sown May 15th, 1896; soil bench land; sandy loam; plants appeared above ground 12 days after sowing; irrigated twice, June and July; used furrow system of irrigating; potatoes grown on same land previous year; depth of plowing 9 inches; thinned June 15th, 1896; did not cultivate; hoed twice; dates of same about June 15th and July 15th; gave fairly good culture; expense of production per square rod 75 cents; dug Oct. 7th, 1896; yield 304 lbs. per square rod.

239—C. L. Tilden, Park City, Yellowstone County. Seed sown May 11, 1896; plants appeared above ground 14 days after sowing; soil sandy, about two feet in depth; irrigated three times by flooding system; oats grew on same land previous year; depth of plowing 8 inches; thinned June 15th, 1896; not cultivated; hoed three times, dates of same June 3d and July 2nd and 28th; gave beets careful and thorough culture; total cost of production per square rod 25 cents; dug Oct. 5th, 1896; yield 600 lbs. per square rod.

240—Taylor Trent, Bozeman, Gallatin County. Seed sown May 15th, 1896; plants appeared above ground 13 days after sowing; soil sandy loam three feet deep; irrigated twice by furrow system; oats were grown on same land previous year; depth of plowing 12 inches; thinned July 1st; cultivated three times; hoed twice; dates of hoeing June 15th and 30th; gave beets careful and thorough cultivation; cost of production per square rod 10 cents; dug Oct. 12th, 1896; yield 50 lbs. per square rod.

241—Lowell M. Jones, Meyersburg, Park County. Seed sown May 20th, 1896; plants appeared above ground 12 days after sowing; soil black 2½ feet deep; irrigated once by furrow system; cabbage grew on same land previous year; depth of plowing 6 inches; thinned June 26th, 1896; cultivated once with hand cultivator; gave beets careful and thorough culture; dug Oct. 5th, 1896.

242—H. L. Slater, Central Park, Gallatin County. Seed sown June 11th, 1896; plants appeared above ground 8 days after sowing; soil sandy; irrigated twice by furrow system; beets grew on same land previous year; depth of plowing 6½ inches; did not thin beets; cultivated twice; hoed once July 1st, 1896; did not give beets thorough and careful culture; dug Oct. 12th, 1896; yield 400 lbs. per square rod

243—Sam'l Bell, Central Park, Gallatin County. Seed sown May, 1896; soil sandy loam 8 inches deep; irrigated twice by furrow system; oats grew on same land previous year; depth of plowing 6 inches; thinned July 3d, 1896; cultivated once; hoed twice; did not give beets careful culture; dug Oct. 17th, 1896; yield 200 lbs. from seed received from Station.

244—W. F. Rose, Duncan, Gallatin County. Seed sown June 4th, 1896; 25 days after sowing plants appeared above ground; parsnips grew on same land previous year; plowed three inches deep; cultivated once; hoed twice; date of hoeing July 14th, 1896; dug Oct. 20th.

245—G. C. Monroe, Spring Hill, Gallatin County. Seed sown May 23d, 1896; soil dark loam 8 to 12 inches deep; irrigated three times by furrow system; beans grew on same land previous year; depth of plowing 8 inches; thinned July 6th; weeded twice; hoed twice, June 24th and July 15th; gave beets careful culture; dug Oct. 10th, 1896.

246—Wm. Blain, Bozeman, Gallatin County. Seed sown May 8th, 1896; plants appeared above ground 11 days after sowing; soil black sandy; irrigated once by flooding system; depth of plowing 10 inches; thinned; bugs destroyed ½ of the beets the third day; cultivated twice; hoed four or five times; dates of same June 13 and 20, August 3d; gave beets careful culture; cost of production per square rod 80 cents; dug Oct. 15th, 1896; yield 50 lbs. per square rod; samples sent in were common red beets.

247—A. L. Corbly, Spring Hilll, Gallatin County. Seed sown June 6th, 1896; plants appeared above ground eight days after sowing; soil loam with clay sub-soil; soil 18 inches deep; irrigated once, July 18th, 1896, by furrow system; potatoes grew on same land previous year; depth of plowing 8 inches; thinned on July 2nd; cultivated twice; hoed once, July 2nd; gave fairly good culture; cost of production per square rod 16⅔ cents; dug Oct. 19; yield 47 7-10 lbs. per square rod.

248—John Harper, Bozeman, Gallatin County. Seed sown June 2nd, 1896; plants appeared above ground 12 days after sowing; soil loam, very deep; did not irrigate; cabbage grew on same land previous year; depth of plowing 10 inches; thinned July 10th; cultivated once; hoed once, July 10th; dug Oct. 29th, 1896; yield 400 lbs. on 1x1½ rods.

249—E. J. Thornberg, Logan, Gallatin County. Seed sown May 22, 1896; soil sandy loam; irrigated three times, last of June and twice in July; cultivated twice; depth of plowing 10 inches.

250—Manhattan Malting Co., Manhattan, Gallatin County. Seed sown May 18th, 1896; plants appeared above ground 11 days after sowing; soil clay; irrigated twice, June and July; mangles grew on same land previous year; depth of plowing 5 to 6 inches; thinned June 5th, 1896; cultivated twice; hoed twice, June and July; dug Oct. 20th, 1896; yield on 5600 square feet 4,000 lbs., or 15½ tons per acre.

251—Geo. W. Spring, Bozeman, Gallatin County. Seed sown May 15th; plants appeared above ground 2 to 3 weeks after sowing; soil all clay with heavy clay sub-soil; irrigated twice by furrow system; corn grew on same land previous year; depth of plowing 7 to 8 inches; did not thin beets; cultivated once; hoed once, last week in June; gave fair culture; dug Oct. 26th.

252—B. M. Dawes, Bozeman, Gallatin County. Seed sown May 20th; plants appeared above ground 10 days after sowing; soil black loam 2 to 3 feet deep; did not irrigate cabbage grew on same land in 1895, depth of plowing 7 inches, thinned July 9th, cultivated once, hoed once, gave beets fair culture, cost of production 50 cents per square rod; dug Nov. 16th.

253—C. W. Reynolds, Bozeman, Gallatin County. Seed sown May 11, 1896; plants appeared above ground 10 days after sowing; soil black loam irrigated twice; cabbage grew on same land previous year; depth of plowing 6 inches; date of thinning June 25, hoed twice.

254—J. M. Robinson, Bozeman, Gallatin County. Seed sown April 10th; plants appeared above ground 15 days after sowing; soil dark loam; irrigated three times—July 8th, 20th and Aug. 10th; no crop on same land previous year; plowed 8 inches deep; thinned May 20th; cultivated three times; hoed once, May 20th; dug Oct. 10th; yield 700 lbs.

TABLE No. 13.

EXPERIMENT STATION CROP OF 1897—VARIETY KLEINWANZLEBEN.

Lab. No.	Description.	Average Weight.	Degrees Brix.	Percent Sugar in Juice.	Purity Coef-ficient.	Percent Sugar in Beet.
460	Dug August 18th, 1897.	5 oz.	.....	17.8	....	16.91
461	Dug August 30th, 1897.	7 6 oz.	21 0	17.4	82 86	16 53
462	Dug Sept. 2d, 1897.	7 4 oz.	.....	17 8	....	16 91
463	Dug August 21st, 1897.	7 2 oz.	25.0	19.2	76 80	18.24
464	Dug Sept. 6th. 1897.	11.0 oz.	19 6	16.0	81 60	15.20
465	Dug Sept. 9th, 1897.	8 0 oz.	19.7	16 0	80.80	15 20
466	Dug Sept. 13th, 1897.	11.0 oz.	19.9	16 2	81 40	15 39
467	Dug Sept. 17th, 1897.	16.8 oz.	19 3	15.4	79.10	14.53
468	Dug Sept. 21st, 1897.	17. oz.	21 3	17 0	79 80	16 15
469	Dug Sept. 24th, 1897.	14. oz.	21.8	18 0	82 50	17.10
470	Dug Sept 30th. 1897.	13 oz.	22.	18 6	84 50	17.67
471	Dug Oct. 2d, 1897.	16 6 oz.	22 2	17.4	78 40	16.53
472	Dug Oct. 5th, 1897.	18. oz.	23.2	20 0	86.20	19.00
473	Dug Oct. 12th, 1897.	31. oz.	20 8	17.4	83 60	16.53
474	Dug Oct. 15th, 1897.	28. oz.	21.	17.	80.90	16.15
475	Dug Oct. 15th, 1897.	26. oz.	19.2	15.2	79 10	14.44
476	Dug Oct. 15th, 1897.	20. oz.	18.8	16 9	89 80	16 05
477	Dug Dec 9th, 1897.	10. oz.	18.8	16.	86.10	15 20
478	Dug Dec. 9th, 1897.	14 oz.	18.0	15 0	83 60	14 25

EXPERIMENT STATION TESTS—SUGAR BEET DATA, 1897.

Sowed May 18th. June 22d cultivated with wheel hoe. July 2d to 6th cultivated with beet weeder. July 12th finished weeding. July 20th cultivated. July 29th weeded. Irrigated Aug. 2d. Cultivated August 11th. Irrigated Aug. 26th. Cultivated Sept. 2d. Yield 27,280 pounds.

Table No 14—Season of 1897.

Lab. No.	Description.	Av. Wght.	Deg. Brix.	Percent Sugar in Juice.	Purity Coefficient.	Percent Sugar in Beets.
430	Manhattan Malting Co.,	25 oz.	19.80	14.00	72.54	13.30
431	Nelson Lundwall	... oz.	21 00	17.80	84.70	16.91
432	Victor E. Cline	18 oz.	18.70	15.00	80.20	14.25
433	Oliver Scow	23 oz.	17.60	14.00	79.50	13.30
434	W. A. Caldwell	31 oz.	15.40	10.60	68 80	10.07
435	C. E. Coleman	44 oz.	15.40	10.20	66.20	9.69
436	W. H. Daykin	22 oz.	19.80	15.20	78.70	14.44
437	W. Spurgin & Son	25 oz.	16.70	11.60	69.40	11.02
438	D. T. Grogan	41 oz.	15.70	11.60	73.80	11.02
439	McNiven Bros.	36 oz.	17.40	11.40	65.50	10.83
440	R. C. and J. T. Smith	45 oz.	16.70	12.00	71.80	11.40
441	J. S. Foster	83 oz.	14.80	10.00	67.50	9.50
442	Geo. J. Allen	18 oz.	20.40	15.00	73.50	14.25
443	J. Briscoe	40 oz.	18.70	14.00	74 80	13.30
444	G. L. Gordon	26 oz.	18.10	14.00	77.30	13.30
445	John Mitchell	32 oz.	17.90	13.40	74.80	12.73
446	Calvin Pixley	42 oz.	16.90	13.60	80.40	12.92
447	Geo. Girder	33 oz.	17.70	14.00	79.10	13 30
448	H. H. Sappington	27 oz.	15.40	10.60	68.80	10.07
449	Manhattan Malting Co.	30 oz.	18.70	14.00	74.80	13.30
450	D. Maynard	7 oz.	18 90	14.60	77.20	13.87
451	W. T. Rose	6 oz.	17 50	14.00	80.00	13.30
452	H. Slater	20 oz.	19.70	16 00	81.20	15.20
453	D. Cameron	48 oz.	15 80	10.30	65.20	9.78
454	Chas. B. Anderson	8 oz.	17.20	13.30	77.30	12.63
455	P. T. Morrison	27. oz.	19.00	14.40	75.80	13 65
456	H. W. Nelson	17. oz.	17.70	14.40	81.30	13.65
457	J. Vestal	33. oz.	15.90	10.70	67 90	10.16
458	J. H. Fisk	28. oz.	18.70	12.50	66.80	11.87
459	E. D. Ferguson	8. oz.	22.00	15.10	68.60	14.34
479	Nelson Lundwall	10.5 oz.	20.00	16.00	80.00	15.20
480	B. M. Dawes	31. oz.	20.00	14.60	70 00	13.87
481	B. M. Dawes	18. oz.	19.00	16.40	86.30	15.58
482	B. M. Dawes	5. oz.	19.80	16.80	84.80	15.96
483	E. Hodgman	5.6 oz.	21.50	17.60	81.80	16.72
484	Alex Budke	10.4 oz.	23.00	18.40	80.00	17.48
485	Geo. A. Bruffy	9.6 oz.	17.40	13.40	77.00	12.73
486	C. A. Hemenway	24. oz.	16.70	12.30	73.60	11.68
487	J. W. Brewer	32 4 oz.	21.00	16.30	77.60	15.49
488	H. S. Bartlett	8.4 oz.	19.80	15.80	74.70	15.01
490	J. H. Foy	27. oz.	19.60	15.00	76.50	14.25
491	Chas. N. Brown	15. oz.	18.30	11.50	62.80	10.93
492	Jas. A. Billings	16.8 oz.	18.00	13.20	73.30	12.54
493	G. R. Smith	54. oz.	17.10	11.90	69.60	11.31
495	W. Jaquette	35. oz.	18.10	14.00	77.30	13.30
496	Robt. C. Palmer	24. oz.	17 70	13.90	78.60	13.21
497	Theo. Konig	45.6 oz.	18.80	14.10	75.00	13.40
498	C. E. Pettit	33. oz.	19.30	15.20	78.70	14.44
499	C. O. Ingalls	24. oz.	18.90	15.80	83.60	15.01
500	J. H. Eayres	26. oz.	19.20	16.10	83.80	15.30
501	A. Truman	16. oz.	18.20	13.80	70.30	13.11
502	A. A. Spaulding	27. oz.	20.00	17.10	85.50	16.25
503	E. H. Thompson	21. oz.	17.00	16 10	94.10	15.30
504	R. A. Baxter	7. oz.	19.00	13.70	72.20	13.01
505	J. A. Moore	8. oz.	17.50	14.00	80.00	13.30
506	W. B. Blackwood	16. oz.	16.00	15.30	95.60	14.54
507	L. B. Wisner	17.. oz.	20.10	16.50	80.00	15.68
508	Manhattan Malting Co.	32. oz.	19.70	16.60	84.30	15.77

TABLE No. 15.

AVERAGES FOR 1897.

Locality.	Average Weight.	Degrees Brix.	Percent Sugar in Juice.	Purity Coefficient.
Montana Exp. Station,	14.8 oz.	20.9	17.1	81.9
Gallatin Valley,	23.4 oz.	18.3	14.4	76.4
Livingston,	24.7 oz.	19.3	14.5	74.3
Kalispell,	32.0 oz.	18.6	14.1	76.2
Missoula,	32.0 oz.	17.0	12.6	73.6

CULTURE NOTES OF CO-OPERATIVE TESTS, 1897.

Lab. No.

430—Manhattan Malting Co., Manhattan, Mont. Planted May 12, 1897; thinned June 27, 1897; harvested Sept. 21, 1897; soil clay, in cultivation for five years chiefly in potatoes; last crop potatoes; no fertilizer used. Plowed Sept. 1896, eight inches deep; seed planted by hand; hoed by hand June 1st, 10th, 20th, July 1st and 15th. Length of rows harvested 75 feet; width between rows 16 inches; number of beets harvested 24,393 per acre; total weight of beets harvested less neck and tops 123 lbs., or 53,580 lbs. per acre, or 26 4-5 tons. Weather for each month, May 1-½ inches rain, June 2¼ inches rain, July ½ inch rain, August ⅛ inch rain, Sept. 1st up to Sept. 21st 1 inch rain.

431—Nelson Lundwall, Bozeman, Mont. Sowed May 20th; light colored soil sandy sediment about 2 inches deep; length of rows 16½ feet; width between rows 21 inches; irrigated three times; July 13, July 31 and August 16, by furrow system. Produced 208⅔ lbs. per square rod; oats grew on same land in 1896; depth of plowing 6 inches; plants showed above ground May 29; thinned June 17; cultivated with Planet Jr. wheel hoe twice, June 11 and July 8; given good field culture.

433—Oliver Scow, Manhattan, Mont. Sowed May 6; soil sandy loam 18 inches deep; rows 150 feet long; width between rows 2 feet; irrigated twice, July 17 and August 12 by furrow system; dug Oct. 11th; yield 425 lbs. in two rows; wheat grew on same land in 1896; depth of plowing 8 inches; plants showed above ground May 15th; thinned June 10th; cultivated with hoe and weeded when thinning June 10th; cultivated July 10th and August 14th.

434—W. A. Caldwell, Bozeman, Mont. Sowed May 10th; soil black loam 18 inches deep with clay sub-soil; rows five rods long; width between rows 3 feet; did not irrigate; dug Oct. 12th; turnips grew on same land in 1896; depth of plowing 7 inches; plants showed above ground May 25; thinned about middle of July; cultivated by hoeing and plowing; cultivated last of July; the beets were plowed once and hoed once.

435—C. E. Coleman, Missoula, Mont. Sowed May 17th, 1897; soil sandy loam, depth 13 inches; length of rows 100 feet; width between rows 18 inches; irrigated three times, June 5, 13 and July 25th; used furrow system; dug Sept. 28th; turnips grew on same land in 1896; depth of plowing 10 inches; plants showed above ground first on June 1st; thinned June 22d; cultivated by hand Planet Jr. cultivator June 7, 15 and July 27th; gave careful and thorough culture.

436—W. H. Daykin, Missoula, Mont. Sowed May 8th, soil brown loam more than three feet deep, length of rows 200 feet; width between rows 16 inches, did not irrigate, dug Oct. 1st, yield 727 lbs. per square rod; carrots grew on same land in 1896, depth of plowing 8 inches, plants showed above ground on May 16th, thinned July 1st, hand cultivator used and cultivated twice, July 10 and August 1st, gave careful and thorough culture, cost to produce per square rod about 50 cents.

437—W. Spurgin & Son, Missoula, Mont. Sowed May 10, 1897, soil black sandy loam about 30 inches deep, length of rows one rod, width between rows 2 feet, did not irrigate, dug September 1; oats grew on same land in 1896, depth of plowing 9 inches, plants showed above ground 28 days after sowing, thinned June 20th, cultivated with cultivator and hoe every two weeks from date of thinning, gave careful and thorough culture, cost of production per square rod 30 cents.

439—McNiven Bros., Livingston, Mont. Sowed May 19th, soil thick bottom land about 4 feet deep, 3½ feet between rows, did not irrigate, there is a slough alongside of beets; dug Oct. 3, land was manured in 1896 and summer fallowed, depth of plowing 8 inches, plants appeared above ground June 1st, thinned June 22nd, cultivated twice with Planet Jr. cultivator and hoe—June 21st and July 9th.

440—R. C. & J. T. Smith, Livingston, Mont. Soil black loam, creek bottom, depth unknown, length of rows 100 yards, width between rows two feet, irrigated twice—July 4 and July 20 by furrow system, dug Oct. 5, cabbage grew on same land in 1896, depth of plowing 7 inches, plants showed above ground June 5th, were not thinned, planted thin, cultivated once with plow, July 12, gave fair cultivation; ground was in good condition, cost of production 6 to 7 cents per square rod

441—J. S. Foster, Willow Creek, Mont. Sowed May 1st, soil alkali about 2 feet deep, length of rows 135 feet, width between rows 2 feet, irrigated once on July 4th by furrow system, dug Oct. 3d, depth of plowing 8 inches, plants showed above ground May 20th, thinned June 15th, gave careful culture, cost of production per square rod 50 cents.

442—Geo. J. Allen, Livingston, Mont. Sowed May 1st, soil limestone, length of rows 8 rods, width between rows 2 feet, irrigated 3 times—May 31st, July 15th and Aug. 2, by furrow system, dug Sept. 28th, depth of plowing 6 inches, plants showed above ground May 31st, thinned July 5, cultivated with plow and hoe, gave careful culture.

443—J. Briscoe, Livingston, Mont. Sowed May 15th, soil sandy loam 10 feet deep, length of rows 150 feet, width between rows 2 feet, irrigated once on July 10th by furrow system, dug Oct. 8th, cabbage grew on same land in 1896, depth of plowing 10 inches, hoed twice, gave beets careful culture.

444—G. L. Gordon, Willow Creek, Mont. Sowed last of April, soil sandy loam 5 feet deep, bench land, length of rows 201 feet, width between rows 16 inches, did not irrigate, dug Sept. 28th, yield per square rod 580 lbs., sugar beets grew on same land in 1896, depth of plowing 8 inches, plants showed above ground on May 15th, thinned last of June, character of cultivation Planet Jr., cultivated twice in June and July, gave beets fairly good culture, cost of production per square rod 50 cents.

446—Calvin Pixley, Missoula, Mont. Sowed May 1st, soil sandy 14 inches to gravel, length of rows 18 rods, width between rows 22 inches, irrigated once on June 10th by furrow system, dug Sept. 30th, 1897, carrots grew on same land in 1896, depth of plowing 8 inches, ten days before plants showed above ground, yield 600 lbs. per square rod, date of thinning May 24, gave careful and thorough culture with garden hand plow.

447—Geo. Girder, Willow Creek, Mont. Sowed May ?, soil sandy loam, irrigated by furrow system, dug Oct. 10th, potatoes grew on same land in 1896, depth of plowing 6 inches, gave scarcely any cultivation.

450—D. Maynard, Bozeman, Mont. Sowed May 15th, soil deep black loam, width of rows 12 inches, irrigated from well, dug Oct. 4th, depth of plowing 12 inches, plants came up in about 7 days, hoed between rows, gave careful culture.

451—W. T. Rose, Duncan, Mont. Sowed May 15th, soil black, mixed with lime and clay, irrigated once, furrow system, dug Oct. 19th cultivated once with hoe, length of row 300 feet, potatoes grew on same land in 1896.

452—H. Slater, Central Park, Mont. Sowed May 4th, soil sandy, irrigated twice on June 11th and July 8th by furrow system, dug Oct. 13th, yield 300 lbs per square rod, peas grew on same land in 1896, depth of plowing 8 inches, number of days before plants came up 14, date of thinning July 12th, not cultivated, hoed once, June 5th.

458—J. H. Fisk, Townsend, Mont. Sowed May 17th, soaked seed 8 hours, soil river bottom, sand and clay loam, length of rows 114 feet, width between rows 21 inches, irrigated same day as planted and also July 5th and Aug. 14th, by furrow system, dug Oct. 26th, yield 490 lbs. from 2 rows 114 feet long, beets grew on same land in 1896; depth of plowing 8 inches, plants appeared above ground May 22d, date of thinning June 15th, cultivated ground with hoe four times, gave good culture.

480—B. M. Dawes, Central Park, Mont. Sowed May 19, soil black loam 2½ feet deep, length of rows 1½ rods, width between rows 21 inches, did not irrigate, dug Nov. 1st, yield per square rod 400 lbs., sugar beets grew on same land in 1896, depth of plowing 7 inches, plants showed above ground May 29th, thinned July 2nd, hoed twice June 1st and 22nd, gave careful culture, cost 25 cents per square rod.

483—E. Hodgman, Bozeman, Mont. Sowed June 1st, soil gravelly loam about 1½ feet deep, length of rows 40 feet, width between rows 21 inches, irrigated twice July 23 and Aug. 10 by furrow system, dug Oct. 16th, beans grew on same land in 1896, depth of plowing 12 inches, plants showed above ground June 15th, thinned July 22, hoed and pulled weeds by hand, cultivated July 21 and Aug. 9, gave careful culture.

484—Alex Budke, Livingston, Mont. Sowed May 15th, soil reddish with some alkali, length of rows 1½ rods, width between rows 21 inches, irrigated three times—July 3d, 20th and Aug. 14th by furrow system, dug Oct. 21, yield per square rod 140 lbs., land was summer fallowed, depth of plowing 6 to 8 inches, plants showed above ground June 4th, thinned June 28th, cultivated by hoeing June 28 and July 11, gave careful culture.

486—C. A. Hemenway, Clyde Park, Mont. Sowed May 22, soil gravelly and sandy 2 feet deep, length of rows 40 feet, width between rows 2 feet, irrigated twice July 16th and August 2nd by furrow system, dug Oct. 6th, no crop on same land in 1896, depth of plowing 10 inches, date when plants showed above ground June 12th, cultivated with a hoe, cultivated twice, did not give careful cultivation.

487—J. N. Brewer, Livingston, Mont. Sowed May 28th, soil sandy loam 12 to 15 inches deep, length of rows 90 feet, width between rows 3 feet, irrigated once July 16th by furrow system, dug Oct. 5th, yield per square rod 150 lbs., potatoes grew on same land in 1896, depth of plowing 12 inches, plants showed above ground June 10th, thinned July 15th, hoed twice June 25th and July 29th, did not give careful culture.

488—H. S. Bartlett, Livingston, Mont. Sowed May 5th, soil ½ clay, ¼ loam, ¼ sand, length of rows 45 feet, width between rows 24 inches, irrigated four times—Aug. 12, 18, 26 and 31st by furrow system, dug Oct. 9th, yield 75 lbs. in all, grass grew on same land last year or 1896, depth of plowing 6 inches, plants showed above ground May 23d, thinned June 23.

489—E. K. Gregg, Kalispell, Mont. Sowed May 10th, soil gravel, light loam 18 inches deep, length of rows 12 feet, width between rows 2 feet, did not irrigate, dug Oct. 4th, garden in 1896, depth of plowing 8 inches, thinned June 1st, hoed once June 1st, did not give careful culture.

491—Chas. N. Brown, Kalispell, Mont. Sowed May 10th, soil Flathead valley hard to describe, length of rows 50 feet, width between rows 20 inches, did not irrigate, dug Oct. 3d, oats grew on same land in 1896, plants showed above ground July 1st, thinned July 10th, character of cultivation hoed and pulled weeds, did not give careful culture.

492—Jas. A. Billings, Holt, Mont. Sowed May 4th, soil black sandy loam, length of rows 10 rods, width between rows 2 feet, did not irrigate, dug Oct. 9th, yield per square rod 400 lbs., potatoes and turnips grew on same land in 1896, depth of plowing 6 inches, plants showed above ground June 10th, thinned July 15th, hoed and plowed four times, gave careful and thorough culture but it was so dry that they did not have a fair chance, cost 10 cents per square rod.

493—G. R. Smith, Kalispell, Mont. Sowed May 15th, soil dark sandy loam, length of rows about 25 feet, width between rows 3 feet, did not irrigate, dug Oct. 5th, garden stuff grew on same land in 1896, depth of plowing about 5 inches, plants showed above ground 10 days after sowing, were not thinned, cultivated twice, did not give careful culture.

495—W. Jaquette, Kalispell, Mont. Sowed May 8th, soil sandy loam 18 inches deep, length of rows one rod, width between rows 18 inches, did not irrigate, dug Oct. 9th, vegetables grew on same land in 1896, depth of plowing 10 inches, plants showed above ground July 10th, thinned July 20th, cultivated twice with hoe July 20th and Aug. 10th, gave careful culture.

496—Robert C. Palmer, Kalispell, Mont. Sowed May 7th, soil sandy loam, 14 inches deep, length of rows 33 feet, width between rows 20 inches, did not irrigate, dug Oct. 14th, yield per square rod 250 lbs., potatoes grew on same land in 1896, depth of plowing 8 inches, plants showed above ground June 1st, were not thinned, cultivated once with hoe June 10th, did not give careful culture

497—Theo. Konig, Kalispell, Mont. Sowed June 13th, soil black loam with sand, length of rows 5 rods, width between rows 2½ feet, did not irrigate, dug Oct. 5th, turnips grew on same land in 1896, depth of plowing 6 inches, plants showed above ground June 22d, cultivated once, did not give careful culture.

498—C. E. Pettit, Kalispell, Mont. Sowed May 10th., soil gravel sand and loam, irrigated three times, August 1st, Sept. 2nd and 25th, dug Oct. 12, carrots grew on same land in 1896, depth of plowing 10 inches, thinned July 15th, hoed once July 3rd.

499—C. O. Ingalls, Kalispell, Mont. Sowed May 1st, soil sandy loam, did not irrigate, dug Oct 8th, wheat grew on same land in 1896, depth of plowing 6 inches, cultivated once.

500—J. H. Eayres, Kalispell, Mont. Sowed May 15th, soil sandy loam, length of rows 12 rods, width between rows 18 inches, did not irrigate, dug Oct. 4th, oats grew on same land in 1896, depth of plowing 7 inches, plants showed above ground June 1st, thinned June 15th, cultivated three times with hoe, did not give careful culture.

501—A. Truman, Springhill, Mont. Sowed May ?, soil black upland 5 feet deep, length of rows two 36 feet, two 26 feet long, width between rows 2½ feet, irrigated by sprinkling, dug last of Oct., yield about 200 lbs. on the rows, celery grew on same land in 1896, depth of plowing 8 inches, cultivated twice with hoe, gave fair culture.

502—A. A. Spaulding, Bozeman, Mont. Sowed May 1st, soil light clay 1 foot deep, length of rows 16 feet, width between rows 2 feet, irrigated twice July 15th and 30th, irrigated by furrow system, dug Oct. 14th, yield 280 lbs. per square rod, potatoes grew on same land in 1896, depth of plowing 8 inches, plants showed above ground about May 15th, thinned June 10th, cultivated four times with garden cultivator and hoe, gave careful culture.

504—R. A. Baxter, Bozeman, Mont. Sowed June 10th, soil clay 5 or 6 feet deep, length of rows 16½ feet, width between rows 3 feet, did not irrigate, dug Oct. 2nd, corn and cabbage grew on same land in 1896, depth of plowing 6 inches, did not thin them, did not give careful culture.

505—J. A. Moore, Belgrade, Mont. Sowed May 26th, soil black loam, did not irrigate, dug Sept. 30th, oats grew on same land in 1896, depth of plowing 8 inches, eight days before plants came up.

506—L. B. Wisner, Bozeman, Mont. Sowed May 14th, soil black loam 2 feet deep, length of rows 30 feet, width between rows 30 inches, irrigated four times—May 14th, June 15th, Aug. 1st, Aug. 18th by flooding, dug Oct. 30th, yield 760 lbs. per square rod, potatoes grew on same land in 1896, depth of plowing 8 inches, plants showed above ground in 14 days, thinned June 21st, cultivated by harrowing June 21st, did not give careful culture.

TABLE No. 16.

CROP OF 1898—MONTANA EXPERIMENT STATION.

Lab. No.	Description.	Ave. Weight of Beets.	Degrees Brix.	Percent Sugar in Juice	Percent Sugar in Beet.	Purity Coefficient.
843	Montana Exp. Station,	26 oz.	16.3	12.5	11.87	76.7
844	" " "	18 oz.	18.1	15.2	14.44	84.0
845	" " "	31 oz.	19.2	15.1	14.34	18 6
846	" " "	17 oz.	18.1	13 6	12.92	75.1
847	" " "	15 oz.	19 8	15.3	14.53	77.2

EXPERIMENT STATION TEST—SUGAR BEET

DATA, 1898.

Date of sowing June 8th and 9th. Out of ground June 19th. Badly cut down by hail June 20th. Cultivated June 25th. Thinned July 1st and 2nd. Cultivated July 9th and 20th. Irrigated July 21st and 23d. Cultivated July 28th and 29th, and Aug. 8th. Irrigated Aug. 10th and 13th. Cultivated Aug. 18th. Harvested Oct. 6th. Yield per acre 12,072 pounds. The late planting and hail storm account for this very poor showing.

TABLE No. 17.
CO-OPERATIVE TESTS, 1898.

Lab. No.	Description.	Weight of Beet.	Degrees Brix.	Percent Sugar in Juice.	Percent Sugar in Beet.	Purity Coefficient.
780	I. D. O'Donnell, Billings,	11 oz.	21.5	13.4	12.70	62.32
781	D. R. Thornber, Chinook,	46 oz.	19.5	16.4	15.58	84 10
782	D. R. Thornber, Chinook,	47 oz.	17.0	12.8	12 16	75.4
830	I. D. O'Donnell, Billings,	18 oz.	15.7	11 3	10 73	71.3
831	I. D. O'Donnell, Billings,	17 oz.	17.0	11.5	10 92	67.6
832	Bitter Root Stock Farm Hamilton, from Exp. Station Seed,	45 oz.	21 0	16 6	15.77	79.1
833	" " "	26 oz.	21 3	16 7	15 86	78.4
834	" " "	31 oz.	22 5	17 3	16.43	76 8
835	" " "	27 oz.	22 3	18.6	17.67	83 4
836	Bitter Root Stock Farm Hamilton, seed bought in Chicago,	59 oz.	14.9	11.3	10.73	71.0
837	" " "	34 oz.	16 8	11.1	10 54	66 1
838	" " "	58 oz.	17.2	12.8	12.16	74 4
839	" " "	74 oz.	14.2	9 5	9.02	66.9
840	Chas. Gardner, 10-acre Farm, Billings,	24 oz.	13.5	8 4	7 98	62.2
841	" " "	31 oz.	15 4	10.3	9 78	66 8
842	" " "	23 oz.	16 5	10 8	10 26	65 4
849	H Buckhouse, Missoula	18 oz.	23 4	21 0	20.23	91.0
862	Bitter Root Stock Farm Missoula,	25 oz.	20.1	18 8	17.86	93.5
875	J. W. Strevell, Miles City,	38⅜ oz.	25 1	20 6	19.57	82 0
876	J. W. Strevell, Miles City,	38¼ oz.	24 1	20.2	19 19	83 4

CULTURE NOTES OF CO-OPERATIVE TESTS. 1898.

781—D. R. Thornber, Chinook, Mont. Sowed June 1st, variety improved Vilmorin, thinned July 13th to 25th, irrigated July 5th, harvested Oct. 14th, shipped sample Oct. 17th, soil sandy loam, width between rows 27 inches, yield 37,461 lbs. per acre.

830—I. D. O'Donnell, Billings, Mont. Variety Vilmorin, planted May 27th, thinned July 11th, irrigated June 14th, June 27th and July 18th, harvested Oct. 20th, shipped Oct. 21st, soil sandy loam, width between rows 28 inches, season favorable.

832—Bitter Root Stock Farm, Hamilton, Mont. Variety Klein Wanzleben and Vilmorin White Imperial, there was no way to distinguish variety in sample, planted May 15th, thinned June 20th, were not irrigated, harvested Oct. 19th, shipped Oct. 19th, soil clay loam, width between rows 36 inches, season favorable.

842—I. D. O'Donnell, Billings, Mont., from Chas. Gardner's 10-acre farm near Billings. Variety Vilmorin; planted June 1st; thinned July 1st, irrigated June 24th and July 24th, harvested Oct. 21st, shipped Oct. 21st, soil sandy loam, alkali, width between rows 28 inches, season favorable.

849—Henry Buckhouse, Missoula, Mont. Planted May 20th, thinned July 9th, irrigated July 15th, harvested Oct. 22, soil sandy loam, width between rows 26 inches, season average, beets were cultivated and irrigated but once, light sandy soil produced best beets.

862—Bitter Root Stock Farm, Hamilton, Mont. Variety Klein Wanzlében, planted May 12th, thinned June 11th, irrigated June 20th, July 14th, Aug. 2d and 22d, harvested Oct. 18th, shipped Nov. 7th, soil loam, width between rows 27 inches, season favorable.

875—J. W. Strevell, Miles City, Mont. Beets planted May 7th, ground manured, pulverized thoroughly, irrigated twice, July and August, new ground broken the previous fall. (See letter in other part of report).

DISCUSSION OF RESULTS—EXPLANATION OF TERMS.

In the first year's work in the laboratory, on sugar beets, we had no press for obtaining the juice, so that the results, as given in the table, are not as complete as in the following years.

The "average weight" was obtained by weighing ten beets of as nearly average size as possible and dividing this weight by ten. When the beets were divided into three classes, large, small and medium, a similar method was pursued.

If at any time less than ten beets were sent, then the weight of all those sent was averaged.

The "per cent. of sugar in the beet" was determined at first direct and represents the number of pounds of perfectly pure sugar contained in one hundred pounds of beets.

Later, after we procured our press, the percentage of sugar in the beet was calculated from the percentage contained in the juice, by multiplying by ninety-five-hundredths, for as the result of many thousand analyses it has been found that the residue from pressing the beet averages five per cent. or one-twentieth of the weight of the beet.

The percentage of sugar in the juice represents the amount of pure sugar in one hundred parts of the juice; for example, in the analysis numbered 479 in tables of analysis, the percentage of sugar in the juice is given as sixteen. This means that in a hundred pounds of juice there are sixteen pounds of pure sugar, and in a ton of juice twenty times sixteen pounds—three hundred twenty pounds.

Not all of the sugar contained in the juice is obtainable, however, the proportion available being dependent upon the relation of the "Degrees Brix," which gives the percentage of all the solid matter, including sugar, contained in the juice, to the percentage of the sugar.

Beside sugar there are mineral salts, nitrogenous matter, etc., held in solution; and it has been found that these substances other than sugar, prevent an equal weight of sugar from being separated in the process of manufacture.

In the example cited above there is twenty per cent. of total solids, which would indicate the presence of four per cent. of other solids than sugar.

The "Coefficient of Purity," or "Quotient of Purity," or simply "Purity," is the value obtained by dividing the percentage of sugar in the juice by the percentage of total solids and multiplying the answer by one hundred, so as to express it in percentage. In the example selected, sixteen, the per cent. of sugar in the juice, divided by twenty, the per cent of total solids, gives eight-tenths, which, multiplied by one hundred, yields eighty per cent., which is the "purity" of this sample. Now this indicates that of the sixteen per cent. of sugar present in the juice but eighty per cent. or four-fifths of the total sugar is obtainable, which means that but twelve and eight-tenths pounds of sugar to the hundred pounds of juice may be saved.

From this it will be seen that the purity coefficient is a very important factor in determining the quality of sugar beets.

VARIETY.

Except where stated orherwise the variety was Kleinwanzleben, which has given the best general results in comparative tests.

TIME OF RIPENING.

The time of ripening has an important bearing upon the question of manufacture of sugar, because each day's work of a manufacturing plant, which must of neeessity remain idle the greater part of the year, represents a profit of five hundred dollars or thereabout. The earlier such a plant can begin work, the more profitable will be the campaign.

An inspection of the table giving the results of the Experiment Farm tests for 1896, shows that beets of fair size and high sugar content are obtainable as early as Sept. 18, which would be an exceptionally early date for the beginning of a fall campaign, and would make it possible to get in the desirable one hundred days run before Christmas. Results from farmers indicate that a factory could certainly be constantly supplied from the first of October.

It must be borne in mind, however, that the increase in sugar is more rapid, as a rule, in the last stages of growth, and that too early harvesting may result in considerable loss of sugar.

Our experience has not fully supported the view that the gain is so very marked in the last stages of growth, for the examples cited above would indicate in their percentage of sugar, that not enough was to be gained by continuance of growth beyond the first of October to compensate for an enforced idleness of a factory for the same period.

YIELD OF CROPS.

Our experience, coupled with the results of co-operative experiments by farmers in all parts of the State, lead us to believe that we are justified in expecting yields of from twelve tons an acre upwards.

The average, we think, may be safely put at fifteen tons an acre, The Manhattan Malting Co., at Manhattan, raised 26$\frac{4}{5}$ tons to the acre, this weight corresponding to the factory weight of topped beets.

For a factory of average size requiring 30,000 tons of beets for a campaign, at least 2,000 acres would be required to be planted to beets to insure the factory sufficient raw material.

CULTURE NOTES.

The reports sent in by the farmers who have co-operated with us show, almost without exception, that the sugar beets were not given the care they require, that they might yield the best results in both weight and sugar contents. It must be constantly borne in mind that large beets are not desirable, medium beets give best results.

In no case, of all notes sent us, do we find evidence that the fall plowing was deep enough. Sugar beet growing is an art that must be acquired by patient study and experiment and it is not to be expected that our present figures should represent the best possible results. If in time sugar beets of standard grade were required, the Montana farmer can, if he will, supply them.

No attempt is made to draw any conclusions from the notes sent in, except to draw attention to the fact that as already noted the care they deserve was not given them. The notes are offered as examples of times of planting, thinning, cultivating, etc., and may prove useful as guides to those who shall experiment along this line in the future.

UNFAVORABLE CONDITIONS.

Occasionally we were hindered in getting crops sown early by unfavorable spring weather, but even under the most unfavorable conditions the crop has ripened.

Early frosts have not been reported as the cause of damage in any case. Insects are not mentioned, except in one case where red beets were grown, and only once have I seen any evidence that they have done harm, and this was where the crop had taken a very poor stand. The insects were noticed in September.

COMPARISON OF RESULTS IN MONTANA WITH THOSE OF OTHER STATES.

The averages in Wisconsin of beets grown on 517 farms in 59 counties were 12.44 per cent. sugar in the juice, with a purity coefficient of 76 per cent.

The following tables of averages represent the character of the sugar beet crop in Montana for 1898.

Omitting samples sent from two ranches where alkali was strong, and one lot where inferior seed was used, the following are the results:

Average weight	29 oz.
Average total solids	22.4 per cent.
Average sugar in juice	18 6 per cent.
Average purity	82 9 per cent.
Average sugar in beets	17.66 per cent.

The Experiment Station results were poorer this year because of late planting, June 8th, and the fact that just as plants were coming through ground a hail storm destroyed them. Station:

Average weight	21.4 oz.
Average total solids	18 3 per cent.
Average sugar in juice	14 34 per cent.
Average purity	78 32 per cent.
Average sugar in beet	13 62 per cent.

Averages from alkali lands and poor seed:

Average weight	37 oz
Average total solids	16.7 per cent.
Average sugar in juice	11.6 per cent.
Average purity	69 4 per cent.
Average sugar in beet	11.05 per cent.

Averages of whole season's crop from all sources, good bad and indifferent:

Average weight	31 oz.
Average total solids	22.82 per cent.
Average sugar in juice	14.56 per cent.
Average purity	76.0 per cent.
Average sugar in beets	13.83 per cent.

Average of best beets from outside with Experiment Station beets:

Average weight	26.2 oz.
Average total solids	20.93 per cent.
Average sugar in juice	17.07 per cent.
Average purity	81.30 per cent.
Average sugar in beets	16.21 per cent.

TABLE No. 18.

RESULTS IN DIFFERENT STATES.

(*Revised from Idaho Bulletin*).

STATES.	Season	Yield per Acre—Tons	No. of Analyses Averaged	Sugar in Juice	Coefficient of Purity	Sugar content of sweetest single beets as analyzed by the Stations
Arizona	1897	15	41	11.80	73.6	17.70
Colorado	1897	16	51	15.50	81.6	23.00
Idaho	1897	15.0	41	15.17	87.55	21.90
Illinois	1897	12.5	314	12.70	76.70	17.50
Indiana	1897	13.0	307	12.80	80.60	22.90
Iowa	1897	22.0	663	13.70	77.40	17.40 (1)
Kansas	1897	....	160	11.88	76.40	.....
Michigan	1897	15.0	465	16.40	84.00	22.30
Missouri	1897	15.0	304	11.14	71.00	21.02
Montana (3)	1898	15.0	...	15.90	81.20	21.30
Nebraska, Average	5 Years	13.0	10,000	13.60	81.50	22.90
Nevada	1897	10.0	19	18.63	.....	23.80
New York, Ithaca	1897	16.9	495	16.91	83.50	21.50
New York, Geneva	1897	12.0	140	15.30	82.50	.....
New Mexico	1897	16.0	274	14.46	78.00	22.5
Ohio	1897	10.0	607	14.00	78.7	20.00
Oregon	1897	18.5	206	15.24	84.36	23.80
South Dakota	1897	21.9	951	16.40	85.60	22.90
Utah	1897	17.2	269	14.24	83.10	23.00
Washington (2)	1897	18.0	521	17.06	91.3	23.60
Wyoming	1897	15.0	34	18.00	82.3	25.50

(2)—Average of ten acre plats. (1)—Average of ten samples. (3)—All co-operative tests for year.

CONDITIONS NECESSARY FOR THE SUCCESSFUL MANUFACTURE OF BEET SUGAR.

Assuming that capital is seeking a locality for the building of a factory for the production of beet sugar, it is interesting to note the conditions which will determine the selection of the site.

1. An abundance of beets of standard grade are required.
2. Transportation to the factory must be cheap; the distance can not be great.
3. An abundance of pure water must be available.
4. Fuel must be cheap.
5. Limestone of good quality must be near at hand.
6. The factory should be located on a railroad, that the product can easily reach the market.
7. There should be a means of disposing of the extracted pulp to stockmen, for use in fattening cattle for market. This stock should be fed on the farms from which the beets are received, in order that the plant food may be returned to the land.

Now can any locality in Montana meet all the above requirements?

We believe there are many sections of the state where it can be done. Being most familiar with the Gallatin Valley, we cite it as an example of what Montana can offer.

Many times the number of acres required to furnish beets to a large factory lie idle each year, under the fallow system prevailing. If a small portion of these lands could be used for raising sugar beets, not only would one or more factories be supplied with raw material, but the problem of transient labor, which so seriously confronts us every fall at threshing time, would in a degree be solved, for more men would be necessary on ranches during the season of cultivation, and these same men would be available for threshing in the fall and for stock feeding in the winter.

The question of improved methods has been touched upon elsewhere.

The Northern Pacific railroad running the length of the valley would afford transportation of the refined product to the market which would be local, for it would take several factories to supply the sugar consumed within the state.

An abundance of pure water may be obtained from the Gallatin river or any of its branches.

The coal mines located just at the edge of the valley would supply all demands at a price which would compare favorably with that paid in any locality.

Very excellent limestone may be obtained in the Bridger mountains near at hand. Following is the analysis:

ANALYSIS OF BRIDGER LIMESTONE.

Silica	0.15 per cent.
Alumina and Oxide of Iron	0.34 per cent.
Lime	54.03 per cent.
Magnesia	0.98 per cent.
Carbonic Anhydride	43.53 per cent.
Moisture, Organic Matter, etc	1.07 per cent.

Nearly all ranchers in the valley own or ought to own stock to which they could profitably feed the pulp, and there would be no difficulty in selling pulp at a reasonable price.

TABLE No. 19.

The following figures give actual working results of a successful factory:

CHINO VALLEY BEET SUGAR CO.

	1894.	1895.
Acres of beets grown	4,778	7,529
Tons of beets produced	43,773	83,035
Average yield of beets per acre, tons	9.16	11.03
Percent of sugar in beets	15	15
Crude sugar per acre, pounds	2,748	3,309
Sugar per acre 80 per cent. pure	2,198	2,670
Began making sugar	Aug. 2	July 9
Finished making sugar	Oct. 24	Nov. 14
Days in operation	85	129
Average weight of beets worked daily, tons	526	644
Average weight of sugar made daily, pounds	111,431	161,129
Total weight of sugar made, tons	4,736	10,393
Average price paid farmers per ton for beets	$4.66	$4.35
Average return per acre	$42.69	$47.9

SUMMARY.

A careful study of the foregoing presentation will justify the following conclusions :

1. Montana conditions are favorable to the production of sugar beets of high sugar content and standard purity.

2. It is clearly demonstrated that greater attention on the part of farmers to the care of the crop would be attended with marked improvements in the quality of the product.

3. Several localities, similar in location and climate to the Gallatin valley, possess all the requirements of sites for the location of beet sugar factories.

4. Sugar beets containing the required amount of sugar and of sufficient purity cannot be grown in presence of excess of alkali.

ACKNOWLEDGEMENTS.

To the farmers of the State who have so kindly aided me by co-operative tests, to the Agriculturists of the Experiment Station who have supplied me with field notes and to my assistant, Mr. Cobleigh upon whom a large portion of the analytical work has devolved, I wish here to express my thanks.

630.679
M9ab

OF MICH.
11 1909

BULLETIN NO. 20.

Montana Agricultural Experiment Station

......OF......

THE MONTANA COLLEGE OF AGRICULTURE.

Fifth Annual Report

...OF...

Treasurer, Director, Horticulturist, Botanist, Entomologist, Chemist and Agriculturist.

BOZEMAN, MONTANA, AUGUST 1898.

ROCKY MOUNTAIN HUSBANDMAN,
White Sulphur Springs,
MONTANA.

Montana Agricultural
EXPERIMENT STATION.

LETTER OF TRANSMITTAL.

BOZEMAN, Montana, August 25, 1898.

To His Excellency, Robt. B. Smith, Governor of Montana:

Dear Sir—I have the honor to transmit to you herewith in accordance with law, the Fifth Annual Report of the Montana Experiment Station.

Respectfully,
S. M. EMERY, Director.

EXECUTIVE BOARD.

LESTER S. WILLSON, President	Bozeman.
PETER KOCH, Secretary and Treasurer	Bozeman.
GEORGE KINKEL, JR., Vice-President	Manhattan
WALTER COOPER	Bozeman
NELSON STORY	Bozeman

EXPERIMENT STATION STAFF.

S. M. EMERY,	Director and Horticulturist.
F. W. TRAPHAGEN, Ph. D., F. C. S	Chemist.
E. V. WILCOX, Ph. D	Biologist.
H. S. JENNINGS, Ph. D.	Botanist
FRANK BEACH, M. S. (resigned April 1, 1898)	Agriculturist
ROBT. S. SHAW, B. S. A.	Assistant Agriculturist.

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

MONTANA EXPERIMENT STATION,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Report of the Treasurer of the Board.

The Montana Experiment Station, in Account with the United States Appropriation, 1897-98.

DR.

To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30th, 1898, as per act of Congress approved March 2, 1887	$15,000	00
To Sales Farm Produce	1,976	22
Total	$16,976	22

CR.

By Salaries	$ 6,894	86
Labor	3,127	52
Publications	404	00
Postage and Stationery	158	05
Freight and Express	206	50
Heat, Light and Water	284	42
Chemical Supplies	551	25
Seed, Plants and Sundry Supplies	414	46
Fertilizers		
Feeding Stuffs	30	70
Library	66	34
Tools, Implements and Machinery	273	18
Furniture and Fixtures	350	63
Scientific Apparatus	1,356	59
Live Stock	16	50
Traveling Expenses		
Contingent Expenses	115	00
Building and Repairs	2,726	22
Total	$16,976	22

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the Experiment Station of Montana for the fiscal year ending June 30, 1898; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000, and the receipts of farm produce to have been $1,976.22, and the corresponding disbursements, $16,976.22, for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

Attest:
PETER KOCH,
Custodian.

Signed:
LESTER WILLSON, }
PETER KOCH, } Auditors.

MONTANA EXPERIMENT STATION.

Bulletin No. 20. *August, 1898.*

Annual Report of the Director for the Fiscal Year Ending June 30, 1898.

STATION STAFF.

The resignation of Frank Beach was accepted April 1st, 1898.

The resignation of H. S. Jennings (who resigned to accept a similar position in Dartmouth College) was accepted June 30, 1898.

Robert S. Shaw, M. S., B. S., was elected assistant agriculturist April 6, 1898.

FARM IMPROVEMENTS.

A cement floor was laid in the swine house at an expense of $100. It is believed, all things considered, that this is the best material for such purpose. In consideration of the high price (ruling in Bozeman) for cement—$6.00 per bbl. for the best Portland—various combinations of cement and sand were used. A part of the floor was made of equal parts cement and sand; a second part was made of one part cement and two parts sand and still another part was made of one part cement to three parts of sand. This work was done between Nov. 9th and 12th. On Nov. 15th the thermometer indicated 23 degrees below freezing, while on the inside of the swine house (this is made of peeled pine logs) it was 13 degrees above freezing. This difference—36 degrees in temperature between outside and inside—is mentioned to show how warm a log building can be constructed. It is supposed that premature freezing of the cement before hardening and drying out has a very injurious effect upon such floor or pavement. Later a stove was set up in the building and fires maintained therein, the surface of the cement floor first being covered to a depth of two inches with sand to prevent drying too rapidly, which also has a tendency to crack and check the cement.

Observations will be taken as to the difference, if any, between those portions of the floor in which cement was used in varying quantities.

GREENHOUSE AND STEAM-HEATING PLANT.

A greenhouse was built, 20x40 feet, inside measurement, quarter pitch to roof, with double thick glass, butted, (i. e., not lapped) with putty between the joints. The roof is set upon hollow brick walls 18 inches thick. Twelve runs of 1¼ pipe under the benches and three runs in the apex of the roof through which hot steam passes, supplies more heat than is required, and it is proposed to duplicate the present house by building one along the west side of same dimensions.

Steam is generated in a 20 H. P. boiler, situated in the basement of the Experiment Station building, some 40 feet from the greenhouse. It also is utilized in heating four stories (18 rooms and halls) in the Experiment Station building. Fuel used is slack coal from the Trail Creek mines. The greenhouse supplies needed facilities in horticultural work as well as timely material for winter classes in the study of botany,

Cost of greenhouse and heating plant—exclusive of boiler in Station building—$1,200.00.

Owing to the excess of bright, warm, sunshiny days, also the comparative mildness of Montana winters, glass possesses a double value in this state in winter forcing, as in the majority of days in January, February and March it was found necessary to shut off the steam to prevent excessive heat in the greenhouse.

CHANGES IN EXPERIMENT STATION BUILDING.

The Entomological and Botanical Departments of the College and Station were too cramped in the proposed new quarters in the new College buildings, so much so that it was seen to be impossible to afford opportunity for extension and for museum facilities. To meet this demand for office, class and museum room purposes, the attic chamber of the Experiment Station building, hitherto used for storage room, was finished off into a main well-lighted room, 22x52 feet, and four closet store rooms 10x20 feet. The former office rooms on main floor of the Station building were converted into suitable living rooms for the Director, and the second story formerly occupied for this purpose was turned over for class rooms for the departments named. Three commodious well-lighted rooms were finished off on west side of the basement floor into offices for the Director and the Agriculturist and a bulletin and library room. This practically doubles the capacity of the Experiment Station building at a nominal cost of $534.00 and brings Station men (with the exception of the chemist, whose laboratory is 300 feet from the Station building,) all under one roof.

FORESTRY DEPARTMENT.

In 1895 experiments were inaugurated with the following timber trees: Soft maple, catalpa, white birch, white elm, white ash, cottonwood, mountain ash, burr oak, English alder, European larch, black cherry. Of coniferous trees, the following: Scotch pine, Austrian pine, white pine, mountain pine, white spruce, balsam fir, white cedar (arborvitae) red cedar, Colorado blue spruce, abies concolor, dwarf pine, Norway spruce, red pine, Douglass spruce. Of these the following have failed to be of satisfactory growth: soft maple, catalpa, white pine, Norway spruce, red pine, white spruce, Douglass spruce, white cedar and balsam fir.

Those giving the best of satisfaction are: white birch, white ash, cottonwood, (the broad leaf) mountain ash, burr oak, European larch, black cherry, abies concolor, Austrian pine, dwarf pine, picea pungens, (Colorado blue spruce) red cedar, Scotch pine, mountain pine. Those doing exceptionally well are: white birch, cottonwood, burr oak, European larch, Scotch pine, Austrian pine, red cedar and Colorado blue spruce.

These trees were originally set for the dual purpose of experimentation and to produce home-grown stock to be used on the Station grounds for wind and shelter belts and ornamental trees.

In deciduous trees, yearlings, and in conifers, two and three year nursery grown trees were set. The conifers had grown for one season in seed beds and had then been transplanted under brush arbors, where they were allowed to stand one or two years. The deciduous trees were about 12 inches in height, while the conifers were from 6 to 12 inches high when set. Varieties adapted to our conditions have done well. Cottonwoods are from 10 to 12 feet in height with a diameter of 3 inches at the collar; oaks, 3 to 4 feet with a diameter of ¾ inches; larch, 5 to 6 feet; Scotch and Austrian pine, 3½ to 5 feet; red cedar and blue spruce, 2 feet. This is a much more satisfactory method for the farmer by which to secure shade and ornamental trees than to set large trees in the first case. Small trees cost from $1.00 to $3.00 per 1,000: freights are inconsequential; the labor of transplanting and cultivation for the period between purchase and development to suitable size for permanent planting is trifling, and results are very satisfactory under ordinary care and treatment.

The success attending this planting was so encouraging that in the spring of 1897, correspondence was entered into with the Chief of the Forestry Division of the United States Department of Agriculture with a view to securing a permanent government forestry plantation. This was successfully terminated, the basis of the transaction being the furnishing by the Department of Agriculture of the nursery stock, of plans for setting and the means for paying labor employed, while the Experiment Station was to supply ten acres of land to be used in the work and the supervision under direction of the Chief of the Forestry Division of the work. Three acres were thus used in 1898, and additional stock, the whole aggregating 35,000 deciduous and coniferous trees were set in blocks and nursery rows.

The stock supplied was not satisfactory and its condition was bad and the results of the first season's co-operation in Forestry work are not at all satisfactory to the Station. This is highly important work and is deserving of the best efforts of the Experiment Station. With a timbered area far in excess of any other state in the Union, it is a lamentable fact that the average farm home, road-sides, pasture fields and corrals are barren of shade and wind breaks.

No matter how fertile the fields, how abundant and pure the water supply, how grand the distant mountain scenery, there must be suitable shade and protection to the farm home and buildings before they can be properly classed as homes. The tree which has been generally set in Montana is botanically termed "*populus angustifolia*," the narrow leafed cottonwood, termed by some, bastard cottonwood.

This tree answers as a temporary makeshift, but it is not a satisfactory shade tree. It is a variation of the broad-leaf cottonwood or “*populus balsamifera*” and has in a marked degree the tendency in all sports to vary in its general make up. Its worst faults are its early maturity and speedy decay, a tendency to cover its stems with rough, unsightly excrescences and to bleed wherever pruned. This excretion of sap is not only injurious to the development of the tree, but it accumulates in a black, viscous sticky form over the stem of the tree, giving a very unsightly appearance to the trunk. The broad-leaf cottonwood is a much better tree for general planting. As a young tree it is inclined to be tender in the latitude of Bozeman, but this difficulty is corrected as the tree ages. Many object to the diffusion of the cotton covered seeds, but this can be avoided by transplanting in nursery rows the young trees and there cultivating until the female tree fruits, then these can be culled out and only male trees, which do not shed cotton, set. The principal merits of this over the native tree is that the tree has a more desirable habit of growth and develops into a stately, handsome tree, valuable not only for lumber but fire wood as well. It is clearer grained and resists snow and wind effects better than the native tree and is readily propagated from cuttings.

ORCHARD TREES.

With time come results from the general planting both of root grafts and the trees set in orchards.

The following are sorts tested in nursery which give promise of value to the Montana planter, hardiness and vigor of growth being considered:

Allen's Choice
Autumn Strawberry
Charlottenthaler
Strawberry Apple
Early Red
Gano
Hubbard Nonsuch
Hibernal
Jacob Sweet
Lawver
McMahon
Mann
Okabena
Pewaukee
Ribston Pippin
Red Astrachan
Rhode Island Greening
Rome Beauty
Salome
Shockley
Talman Sweet
Transcendent
Wolf River
Walbridge

Alexander
Arkansas Beauty
Clayton
Duchess
Florence Crab
Greenwood
Huntsman
Hersey Sweet
Lady Elgin
Montreal Beauty
McIntosh
Northwestern Greening
Price's Sweet
Pumpkin Sweet
Red Bietigheimer
Ramsdell Sweet
Roman Stem
Rawles Janet
Smith's Cider
Stark
Tetofsky
Utter's Red
White Arctic
Wealthy

Autumn S. Pearmain
Arkansas Black
Early Harvest
Strawberry Crab
Fameuse
Hughes Virginia
Hyslop
King
Longfield
Minkler
Martha
Northern Spy
Plumbs Cider
Perry Russet
Rambo
Roxbury Russet
Rolfe
Stump
Scott's Winter
Spitzenburgh
Twenty Ounce
Van Wyck
Whitney
Yellow Transparent

These sorts are behaving well in orchard as young trees, and give promise of being worthy of trial:

Variety.	SET.	ALIVE.	DEAD.
Yellow Crimean	5	5	
Red Queen	6	6	
Grandmother	5	3	2
Gipsy Girl	5	4	1
Bogdanoff	5	5	
Persian	5	5	
Royal Table	5	4	1
12 M	5	4	1
Rambour Queen	5	4	1
No. 257	5	4	1
Borsdorf	4	1	3
Longfield	3	2	1
Wealthy	5	5	
Alexander	2	2	
Tetofsky	5	3	2
Arabskoe	2	2	
Fameuse	2	1	1
Cross	1	1	
Gideon	3	3	
Veronisch	11	7	4
Anisette	4	3	1
Zuzoff	5	2	3
Aport	5	5	
Baiken	5	4	1
Rosentragen	5	3	2
Orel No. 11	5	3	2
Good Peasant	5	5	
Lead 3 N	7	6	1
Walbridge	2	1	1
Northern Spy	2		2
Gravenstein	2		2
Veronisch Rosy	3	3	
Grimes' Golden	2		2
Red Bietigheimer	2	1	1
Hurlburt	2		2
Fall Pippin	2		2
Ben Davis	2	2	
Golden Russet	5	3	2
Keswick Codlin	2	2	
Red Astrachan	2	2	
Haas	3	1	2

Okabena	3	3	
Thompson's	24	7	17
Sutton Beauty	2		2
Maiden Blush	2		2
Duchess	5	5	
Scott's Winter	3	1	2
Wolf River	3	1	2
Hibernal	3	3	
St. Lawrence	2	1	1
Talman Sweet	2	2	
Yellow Transparent	2	2	
Pewaukee	2	1	1
Total	214	143	71

PEARS.

Variety.	SET.	ALIVE.	DEAD.
Giffard	2	2	
Frederick Clapp	2	2	
Flemish Beauty	2	2	
Tyson	2	1	1
Winter Nelis	2	1	1
Anjou	2	1	1
Boussock	2	2	
Doyenne d Ete	4	3	1
Augouleme	2	1	1
Sheldon	2	2	
Seckel	2	1	1
Lawrence	2	1	1
Total	26	19	9

CRAB APPLES.

Variety.	SET.	ALIVE.	DEAD.
Pride of Minneapolis	3	1	2
Whitney	5	4	1
Hislop	2	2	
Transcendent	5	5	
Greenwood	3	3	
Bailey's Crimson	3	1	2
Martha	3	3	
Virginia	3	1	2
Orange	3	2	1
Early Strawberry	3	3	
Total	33	25	8

CHERRY TREES.

Variety.	SET.	ALIVE.	DEAD.
Yellow Glass	5	4	1
Orel No. 24	5	2	3
Slanka	5	4	1
Amarilla	2	2	
Lutovka	5	4	1
Griotte du Nord	5	4	1
Bessarabian	5	4	1
Black Tartarian	3	1	2
Griotte Precose	5	2	3
King's Morello	5	4	1
Royal Duke	2	1	1
Wragg	3		3
May Duke	2		2
Ostheim	3		3
Windsor	1		1
Tradescant	2	2	
Montmorency	2	2	
E. Richmond	2	2	
Total	62	38	24

APRICOTS.

Variety.	SET.	ALIVE.	DEAD.
Gibb	3		3
Alexandria	3	1	2
Budd	3		3
Total	9	1	8

PRUNES.

Variety.	SET.	ALIVE.	DEAD.
George Glass	3	3	
Hungarian	15	10	5
Communia	8	1	7
Total	26	14	12

PLUMS.

Variety.	SET.	ALIVE.	DEAD.
Tatge	3	3	
Charles Downing	2	2	
Spanish King	1	1	
Riga No. 118	5	2	3
Wilson	1	1	

Moldovka	5	5	
Ogon	5		5
Wyant	2	1	1
F. Garden	3	1	2
Milton	3	3	
Yellow Veronisch	5	5	
Hammer	3	3	
Maquoqueta	5		5
Yellow Glass	7	6	1
Wild Goose	3		3
Wolf	3		3
Rollingstone	3		3
McLaughlin	2	1	1
Desota	8	3	5
Weaver	3	3	
Hawkeye	3	2	1
Smith's Orleans	2		2
Lombard	2	1	1
Green Gage	3	2	1
Coe's Golden Drop	2	1	1
Bavay's Green Gage	2	2	
Fellemburg	2	1	1
Peter's Y. Gage	2		2
Total	90	49	41

A study of the trees set in orchard in 1895 will show those which have proven hardy so far, under such climatic conditions as have prevailed during this period.

There have been no abnormal climatic extremes, but the lowest temperatures—29° and—24° have come in 1896 and 1897, in November, before the maturing of the young wood had fully occurred, and it is considered that such conditions are peculiarly trying to fruit trees.

We think also that some trees have died owing to irrigation having been prolonged too late into the season.

In 1895 and 1896 the trees were irrigated as late as August 13th, while now the practice is to permit no water to flow later than July 31. During the months of August and September the nights are too cold to permit of ripening of wood, and the same causes which prevent ripening also prevent undue evaporation of moisture, hence the necessity does not exist for late watering.

In the event of the leaves remaining green and vigorous and the young growth of wood plump and full, water is not a necessity but in the event of the leaves yellowing in August, it is then well to administer a light, quick watering which will cause such conditions to cease. Full rank growth of the young tree is not a necessity where irrigation is practised. Under good cultivation the older the tree (up to full maturity) the stronger the growth, and there is more to be apprehended from too strong a growth than from the reverse.

From the experience in this Station we think there is no question but that trees of following varieties, tested on our grounds, can be safely planted in similarly situated locations, and that they will come to fruiting provided there be no severer weather than that of '95 and '96.

Of Russians—Yellow Crimean, Red Queen, Bogdanoff, Persian, Arabskoe. Aport, Good Peasant.

Of other Standard Apples—Wealthy,* Alexander, Gideon, Ben Davis, Keswick Codlin, Red Astrachan, Okabena, Duchess, Hibernal, Talman Sweet, Yellow Transparent.

Of Crabs—Whitney, Hislop, Transcendent, Greenwood, Martha. Early Strawberry.

Of Pears—Giffard, Flemish Beauty, Boussock, Angouleme, Sheldon.

Of Cherries—Amarilla, Lutovka, Montmorency, Bessarabian, E. Richmond.

Of Plums--Moldovka, Yellow Veronisch, Weaver, Hawkeye, Lombard.

Of Prunes—George Glass, Hungarian.

The following varieties have fruited the present season: Duchess, Transcendent, Hislop, Whitney, Early Strawberry, Greenwood, Orange.

It is highly important that plums and prunes be tested as to the period for ripening their fruits, as it is feared that those of the same season and type of the Weaver and Desota, are not going to fully mature their fruits for reasons previously stated.

So far no instances of leaf blight upon apples or crabs have been noted by Station workers in Montana. We request that the Station be promptly notified of any instances that may pass under the observation of Bulletin readers. This is manifested by the leaves dying within 24 hours and hanging onto the twigs as dead and sere as if it were December. In severe cases the young growth dies completely, the bark turning brown and shrivelling up, the same as if it had been severed from the tree. This is a bacterial disease, and is very contagious. It is said that a drop of sap from an affected tree may be diluted in distilled water 1,000 times, and if the point of a cambric needle be dipped into the solution and then thrust into the bark of the young growth of a tree, not affected, that inoculation will at once occur and the tree speedily be stricken with blight.

Altitude has been supposed to be a preventive to its ravages; but this is not so, as hundreds of thousands of trees in Colorado in higher altitudes than Montana are suffering from the effects of blight. We believe that future immunity from the many insect and fungous and bacterial diseases depends upon Legislative action, which will make it possible to prevent the introduction of infested fruit trees and plants, also that the danger is greatly lessened by planting clean, home-grown stock. Montana-grown trees are, so far as observed, clean and free of the more dangerous insect and fungous pests.

STRAWBERRIES.

Light is needed as to the age to which strawberry beds can be profitably maintained without renewal. Estimating the cost of plants at $3 per thousand, as low a cost as can be reasonably expected for good, "true to name" plants, well packed, the expense of a bed at the end of the first year from setting is not far from $100 per acre.

This is a heavy tax and the longer that a bed can be made profitable the more desirable it is for the producer.

Records, at first bloom period and amount of fruit from 25 plants have been maintained upon the same bed for three succeeding seasons and are presented herewith.

Record first bloom period and yield of fruit from twenty-five plants from a three-year-old bed :

Variety.	Date of First Bloom.	Yield. Pounds.	Yield. Ounces.
Arrow	June 8th	2	3½
Belmont	June 9th	6	3¼
Belle	May 31st	18	13⅜
Banquet	June 1st	4	11⅛
Bisel	May 30th	27	14½
Brandywine	June 1st	5	10⅛
Bubach No. 5	May 30th	23	14⅜
Bartons Eclipse	May 22d	4	13¼
Beverly	May 20th	19	12
Bederwood	May 14th	33	8

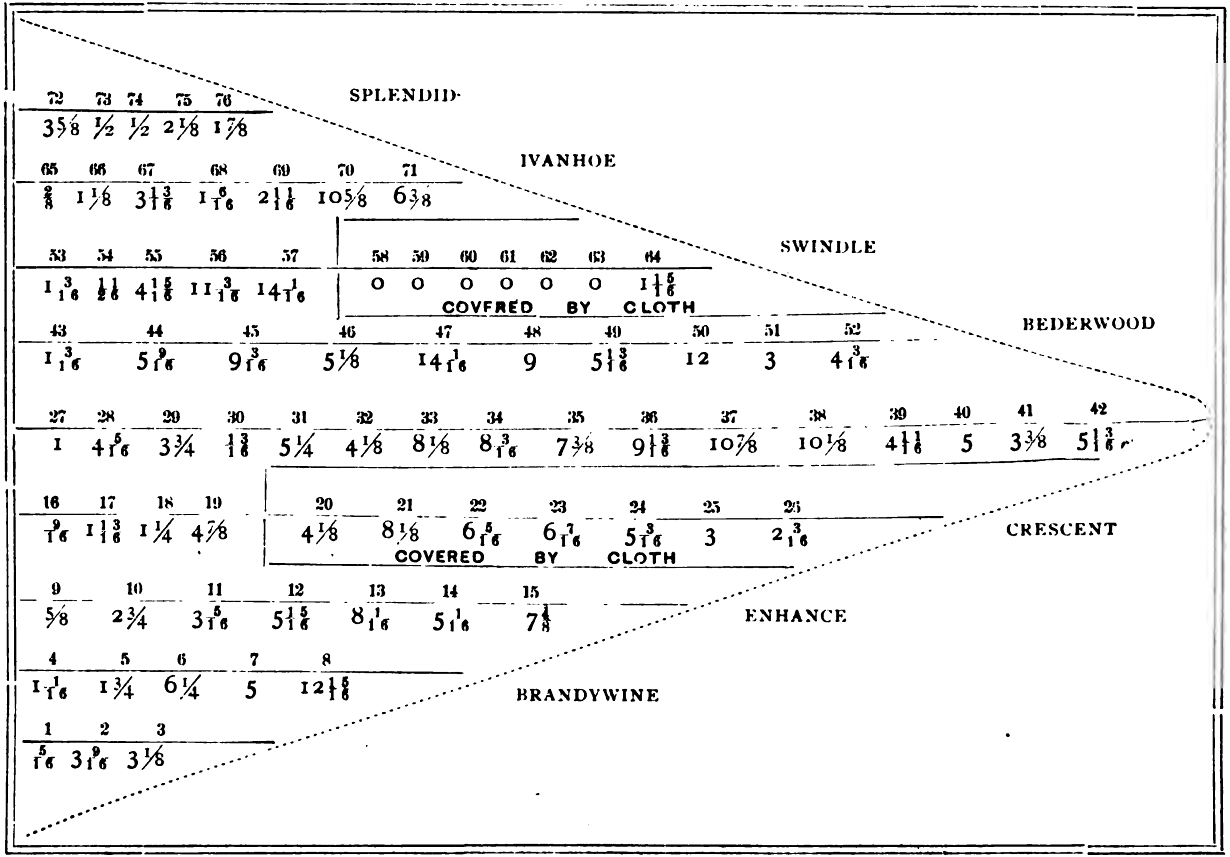
Crescent	May 20th	8	6
Cyclone	June 3d	18	13⅛
Crawford	May 23d	14	3¾
Columbian	June 6th		13⅝
Chair's	June 9th		14⅝
Dayton	May 30th	7	4⅞
Enormous	June 8th	10	15½
E. P. Roe	May 20th	10	
Eureka	June 1st	12	7⅝
Enhance	May 20th	24	14
Edgar Queen	May 31st	5	9½
Governor Hoard	May 20th	11	4½
Gillespie	June 8th	3	9⅛
General Putnam	May 22d	4	8¾
Greenville	June 8th	7	2⅛
Gandy Belle	June 6th	23	5⅛
Great Pacific	June 1st	5	14¾
Gandy	June 9th	8	15
Haverland	May 20th	5	10
Hoffman	May 31st	3	14⅞
Ivanhoe	May 30th	15	⅛
Jay Gould	June 9th	4	5½
Klickitia	May 30th	11	10⅝
Leader	May 31st	22	15¾
Lovett	June 1st	11	12½
Michele Early	May 16th	10	8
Meeks Early	May 31st		11¾
Muskingum	June 8th	4	14⅛
Mrs. Cleveland	June 9th	6	11⅞
Princess	May 28th	13	7½
Princeton Chief	June 8th	7	10⅝
Parker Earle,	June 2d	10	3¾
Paris King	May 31st	8	5⅝
Rio	May 22d	8	15¼
Robinson	May 26th	9	8⅝
Sandoval	June 1st	6	3¼
Stevens	June 7th		1
Shuster Gem	May 31st	10	⅝
Sharpless	June 1st	6	2¾
Stayman No. 1	May 20th	19	9¾
Splendid	May 23d	32	11⅛
Swindle	May 20th	20	13⅛
Timbrell	May 23d	8	1
Tennessee Prolific	June 8th	8	1⅞
Victor Hugo	May 26th	1	10⅝
Van Deman	May 23d	12	5⅝
Wilson's Albany	May 31st	8	5⅜
Warfield	May 26th	10	13⅛

In addition to a study of the former beds, set in 1895, there have been set 41 new varieties to be made a part of the experiment work of the Station. The best is none too good for the Montana berry grower and new lists from reliable growers will be closely scanned for such kinds as seem to possess merit. The strawberry of all fruits is seldom able to assert its individuality irrespective of locality, and for this reason we consider it highly essential to extend rigid tests.

The following is the list of names and number of each variety set spring 1898:

Variety.	No. of Plants.	Variety.	No. of Plants.
Anna Kennedy	8	Marshall	9
Blonde	7	Morgan's Favorite	6
Bismark	7	Margaret	1
Brunette	4	NickOhmer	5
Carrie	8	Ocean City	6
Clyde	5	Patrick	7
Drought King P	7	Ponderosa	5
Evans	8	Ridgeway	7
Edith	9	Ruby	3
Gertrude	8	Saunders	9
Giant	5	Sparta	6
Gardner	5	Sunrise	10
Glen Mary	0	Satisfaction	9
Halls Favorite	1	Staples	9
Jersey Market	11	Sunnyside	6
Jessie	3	Seek no Further	3
Kingsworth	4	Star	7
Lady Thompson	6	Tubbs	5
Lehigh	6	W. M. Belt	8
Manwell B	7	Woolverton	8
Michigan B	3	Youngs Early Sunrise	4
Murray	10		

By reference to Bulletin No. 16, (4th annual report) it will be noted that a bed of Crescent seedling strawberry plants was set in a triangle to determine the distance that should separate pistillate and staminate plants to secure pollination. Herewith is presented a chart showing the individual plants from No. 1 to 76 inclusive, together with the yield of fruits in ounces and fractions of each plant in the test:


SPLENDID
72 73 74 75 76
3 5/8 1/2 1/2 2 1/8 1 7/8
IVANHOE
65 66 67 68 69 70 71
2/8 1 1/8 3 13/16 1 6/16 2 11/16 10 5/8 6 3/8
SWINDLE
53 54 55 56 57
1 3/16 11/16 4 15/16 11 3/16 14 1/16
58 59 60 61 62 63 64
0 0 0 0 0 0 1 15/16
COVFRED BY CLOTH
BEDERWOOD
43 44 45 46 47 48 49 50 51 52
1 3/16 5 9/16 9 3/16 5 1/8 14 1/16 9 5 13/16 12 3 4 3/16
27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42
1 4 5/16 3 3/4 13/16 5 1/4 4 1/8 8 1/8 8 3/16 7 3/8 9 13/16 10 7/8 10 1/8 4 11/16 5 3 3/8 5 13/16
CRESCENT
16 17 18 19
9/16 1 13/16 1 1/4 4 7/8
20 21 22 23 24 25 26
4 1/8 8 1/8 6 5/16 6 7/16 5 3/16 3 2 3/16
COVERED BY CLOTH
ENHANCE
9 10 11 12 13 14 15
5/8 2 3/4 3 5/16 5 15/16 8 1/16 5 1/16 7 1/8
BRANDYWINE
4 5 6 7 8
1 1/16 1 3/4 6 1/4 5 12 15/16
1 2 3
5/16 3 9/16 3 1/8

These plants were in 9 rows, 5 feet apart, and the pollenizing plants were the Splendid, Ivanhoe, Bederwood, Enhance and Brandywine. In addition to gaining some light upon this proposition it was farther determined to seek light upon the work of insects in pollenizing fruit blooms by the transference of pollen from staminate to pistillate plants. For this test plants Nos. 58, 59, 60, 63, 64 and 20, 21, 22, 23, 24, 25 and 26 were covered with cheese cloth netting, Strips a yard wide were used, the meshes being $\frac{1}{16}$ of an inch in diameter. These were spread along the rows and weighted down with stones on ends and sides. During a wind squall the strips covering plants 20 to 26 inclusive were blown up at one side so as to expose these plants to insects. It was not noticed until two days later, during which interim the blooms upon these plants were fertilized so as to give quite a fair average crop of fruit. However, the strips covering plants Nos. 58 to 63 inclusive, remained in place and not a berry was produced thereon. There were a few aborted berries, but very imperfect, not such as could be classed as edible. This fact, taken in connection with the irregular fruitage of the plants throughout the test, give tangible evidence that pollenization depends quite as much upon the work of insects as upon the movement of air, and the transference of pollen by wind. It is interesting to note that while the Crescent is the best type of pistillate plant, that not a single one of the 76 plants set, (except those under the cheese cloth), failed to mature some fruit, although some of the plants were from 20 to 27½ feet distant from any staminate plants.

Farther work is needed to demonstrate the important point of pollenization, and in a new bed to be used in this work a different form from the triangular will be used and a coarser cloth employed to ward off insects. It might have been that the chese cloth meshes were too small to permit the successful sifting or straining through of the pollen dust.

By studying the chart it will be observed that much the heaviest fruitage occurred in the near vicinity of the portions of rows covered by cheese cloth. It was as if pollen laden insects had been attracted by the white covering of cheese cloth and had traveled over it to sides or ends and failing to get entrance to the protected blooms underneath had moved to the plants the nearest thereto, If it be true, as is claimed by old strawberry growers, that the pistillate plants when properly fertilized, are much the best yielders, it certainly is desirable to attempt the solution of the profitable per cent of staminates to be set with pistillates to secure the best paying results. It was not possible to continue observations upon the difference in varieties to frost resistance as the usual white frost which occurs about the time strawberries are cleverly in bloom did not occur the present season. This is an important work and will be continued as opportunity offers.

S. M. EMERY, Horticulturist.

FARMERS' INSTITUTES.

These important meetings have not been carried on during the current year for reasons beyond control.

There is much valuable work going on at any live Station which never appears in bulletin form simply because there are financial limitations to the publication of bulletins. Such can be better given to interested farmers by word of mouth than in any other form, as this gives opportunity for full and free discussion of methods and progress. It further enables the Station staff to gain much valuable information from the farmers, to rightfully estimate the capacity and adaptation ot of soils to specific crops, and if rightly conducted is one of the most available educators. When existing obstacles are overcome the staff of the Experiment Station is at the service of the farmers of Montana, subject to other official engagements and suitable provision for actual travel expenses incurred in attendance upon such meetings.

PRESS LIST.

We desire to express our sense of obligation to the publishers who have sent their publications to the Experiment Station in exchange for its bulletins; also to advise that the members of the Station staff take pleasure in contributing to the press upon request for publication upon subjects in line with their Station work. The columns of the agricultural press of the country contain much valuable matter derived from Station work, and there can be no better method than this of keeping the public advised of the results of investigation and experiment.

Democrat-Messenger, Missoula.
Independent, Helena.
Inter Mountain, Butte.
Missoulian, Missoula.
Standard, Anaconda.
American Agriculturist, New York City.
Northwest Agriculturist, Minneapolis.
Agricultural Student, Columbus, O.
Breeders' Gazette, Chicago.
Butchers' Advocate, New York.
Cotton Planters' Journal, Memphis.
Dorset Courier, Washington, Pa.
Dixie Miller, Nashville, Tenn.
Elgin Dairy Report, Elgin, Ill.
Farmers' Magazine, Springfield, Ill.
Farm and Home, Springfield, Mass.
Field and Farm, Denver, Col.
Farm News, Springfield, O.
Farmers' Voice, Chicago, Ill.
Farm, Stock and Home, Minneapolis.
Farming, Toronto, Ontario.
Farmers' Guide, Huntington, Ind.
Farmers' Call, Quincy, Ill.
Farming World, Clinton, Iowa.
Florists' Review, Chicago, Ill.
Gardening, Chicago, Ill.
Garden and Field, Adelaide, New South Wales.
Gentlemen Farmer, Chicago, Ill.
Green's Fruit Grower, Rochester, N. Y.
Homestead, Des Moines, Iowa.
How to Grow Flowers, Springfield, O.
Hoard's Dairyman, Fort Atkinson, Wis.
Forester, Philadelphia, Pa.
American Florist, Chicago, Ill.
Farm Journal, Philadelphia, Pa.
Farm Students' Review, St. Anthony's Park, Minn.
Holstein Register, Brattleboro, Vt.
Home and Garden, St. Paul, Minn.
Home and Farm, Louisville, Ky.
Horticultural Visitor, Kinmundy, Ill.
Irrigation Age, Chicago, Ill.
Industrialist, Manhattan, Kan.
Jersey Bulletin, Indianapolis, Ind.
Montana Fruit Grower, Missoula, Mont.
Northwest Farmer, St. Paul, Minn.
Nebraska Farmer, Omaha, Neb.
Rocky Mountain Husbandman, White Sulphur Springs, Mont.
National Stockman and Farmer, Pittsburg, Pa.
North American Horticulturist, Monroe, Mich.
Utah Farm and Church, Salt Lake City, U.
Wallaces' Farmer, Des Moines, Iowa.
Wisconsin Agriculturist, Racine, Wis.
Wool Record, New York.
Western Fruit Grower, St. Joseph, Mo.
W. Va. Farm Review, Charleston, W. Va.
Farm and Poultry, Boston, Mass.
Up to Date, Indianapolis, Ind.
Inter Mountain Poultryman, Tiffin, O.
Inter Mountain Poultry Journal, Spokane, Wash.
Oregon Poultry Journal, Salem, Ore.
American Poultry Journal Chicago, Ill.
Poultry Keeper Parkersburg, Pa.
Poultry Monthly, Albany, N. Y.
American Poultry Journal, Chicago, Ill.
Poultry Culture, Kansas City, Mo.
Pacific Poultryman, Tacoma, Wash.
Poultry Herald, St. Paul, Minn
The Feather, Washington, D. C.
Weekly Sun, Baltimore, Md.
Republican, Lake City, Minn.
Lumberman, Stillwater, Minn.
Northwest Magazine, St. Paul, Minn.
The World, Vancouver, B. C.
Avant Courier, Bozeman.
Belt Valley Times, Belt.
Times, Billings.
Pioneer, Big Timber.
Chronicle, Bozeman.
Opinion, Chinook.
College Exponent, Bozeman, Mont.
Examiner, Dillon.
Tribune, Dillon.
News, Great Falls.
Inter Lake, Kalispell.
Independent, Glendive.
Post, Livingston.
Enterprise, Livingston.
Mining World, Butte.
Journal, Milwaukee, Wis.
Madisonian, Virginia City.
Northwest Tribune, Stevensville.
Riverside, Redwing, Minn.
Picket, Red Lodge.
Sentinel, Gebo, Mont.
Sentinel, Boulder.
Stock Growers' Journal, Miles City.
Tribune Review, Butte.
Tribune, Great Falls.
Western News, Hamilton.
Yellowstone Journal, Miles City.
The News, Miles City.
Herald, Neihart.

Orange Judd Farmer, Chicago, Ill.
Prairie Farmer, Chicago, Ill.
Park and Cemetery, Chicago, Ill.
Rural New Yorker, New York.
The Farm Home, Springfield, Ill.
Agricultural Epitomist, Indianapolis, Ind.
Ruralist, Federalsburg, Md.
Strawberry Culturist, Salisbury, Ind.
Stockman and Farmer, Helena, Mont.
Success with Garden, Reed City, Mich.
Democrat, Lewistown.
Market Garden, Minneapolis, Minn.
Field and Stream, New York City.
Strawberry Specialist, Kittrell, N. C.
Swine Breeder's Journal, Lincoln, Neb.
The National Nurseryman, Rochester, N. Y.
The News, Libby.
News Letter, Plains.
Oregon Agriculturist, Portland, Ore.
Northwest Horticulturist, Tacoma.

BULLETINS.

The following bulletins have been issued during the current year:

Bulletin No. 17—"The Grain Aphis, and Army Cut-Worm," 18 pages, illustrated, by Dr. E. V. Wilcox.

Bulletin No. 18—"The Alkali Soils of Montana," 32 pages, by Dr. F. W. Traphagen.

Bulletin No. 19—"The Sugar Beet in Montana," 40 pages, by Dr. F. W. Traphagen.

Bulletin No. 20– Fifth Annual Report of the Montana Experiment Station, 34 pages.

These are all issued in editions of 6,000 copies, and when the regular mail lists are filled there are less than 200 extras left on hand to supply future demand. Bulletins Nos. 6 and 9 are exhausted. Full files, with the exception of these numbers, can yet be supplied upon demand to those who would appreciate the same. It is important that bulletins be preserved as it is now practically impossible to secure full files of any of the older Experiment Station publications.

Respectfully submitted,
S. M. EMERY, Director.

PLAT GRAINS—ROOT AND GRASS PLATS.

The Station is carrying on its usual observations in these leading farm crops. Ample notes are taken annually of the behavior of the respective varieties and these will eventually be tabulated and published in evidence of what we consider, all things being considered, as the most promising for general cultivation.

Each year additions are made of sorts giving unusual promise, as such information comes to us, and the concensus of the various annual determinations will be a safe guide to the selection of those of promise.

In estimating as to the rate of yield per acre it is to be remembered that we are not alone endeavoring to decide the best varieties in respect to quality and yield, but we are also purifying the seed grown. This is done by scrupulously removing such heads of grain which show to be foreign to the variety in question. This is done at the expense of the stand of grain and consequently detracts from the yield in the proportion that admixture is found to exist. Abnormal culture is not given the plats, as it is not desired to give them undue advantage over and above common farm crops. This statement should be modified perhaps to the extent of stating that the plats are kept free of weeds and foreign growth, also that the rows are drilled 14 inches apart, with a three-foot space between varieties. This gives the outside rows a better opportunity to stool and to head. The performance of these outside rows prompts the opinion that on clean lands under irrigation that the usual distance of drill rows, for small grain, 14 inches, might be profitably increased to 16 to 18 inches; less seed would be thus required and a stronger growth of grain secured.

Rotation of test crops is practised to not only give the varieties a better show, but to gradually extend over the Station farm a cleaner culture than is practical in general farm practise. Between 10 and 12 acres of land are annually used in plat work, and while the results in the past five years are not particularly encouraging as to the extermination of the wild oats and sunflowers, our worst pests in this valley, still some improvement is noted along these lines.

The discouraging feature in both of these plants is that the seeds apparently are able to lie in the ground for any length of time without injury to the germ of the same. A very encouraging feature of the plat cultivation is the interest shown by the farmers of Gallatin county in the work, who are by location able to inspect the fields without much attendant loss of time. The prominence attaching to the barley crops of Gallatin county in the past three years has aroused new interest in our farmers in the study of the different barleys.

In 1893 expert chemists, in the employ of the Brewers' Association of Berlin, visited Gallatin valley and made an exhaustive study of the plant, the berry and the conditions under which it is here grown. Their report to the Association was supplemented by Bulletin No. 7. of this Station, containing yields and chemical analysis of Station grown wheats, oats and barleys, together with private reports and circulars of the Director of this Station, upon the subject of barley production in the Gallatin valley.

The final report of the Brewers' Association of Berlin was issued in 1897, in German text, to its members. In a quiet sort of way this report had been anticipated by its members, and new barley buyers were upon the ground in '95 and '96, but the '97 report seemed to so arouse attention to the crop that the price which opened at 75 cents per 100 lbs. in October, and at which rate a small per cent of the crop changed hands, was rapidly carried to $1.00, $1.10, $1.15 and $1.20 per 100 lbs., the average price paid perhaps being $1.10 per 100 lbs. This price netted the Gallatin County farmer perhaps double the price per pound that was paid the farmers of Minnesota and Wisconsin for their crops.

Montana barley will usually grade strictly No. 1, while the best grade ever sold in the great barley markets of the middle west is No. 2, there being between the two grades a legitimate difference of about 30c per 100 pounds; but the fact becomes more astonishing when it is stated that it costs 42 cts. per 100 lbs. to move Gallatin barley as far east as Duluth and that the difference in grade alone would not be sufficient to offset this difference in freight into 12 cts. per 100 lbs., and that this difference was lost sight of entirely and a double value placed upon Gallatin valley is a strong tribute to the inherent value of our barley.

It is a safe estimate that the farmers of Gallatin county have profited financially by the work of agricultural experts in a sum of money from a single crop adequate to support the Experiment Station for ten years. The handsome price received for barley has not turned the heads of our farmers nor caused them to engage recklessly in barley culture. To the contrary, they are preserving a wholesome equilibrium between the three leading cereals—wheat, oats and barley.

Many are increasing the borders of their meadows, especially of the legumes.

ROTATION TESTS.

Very encouraging results were obtained on this the first year of the six-acre six-year rotation tests. It will be noted by referring to the Fourth annual report, that the land selected for this experiment was seeded to fife wheat in 1896, producing an average crop of 20 bushels upon the tract. The land in question is good average land as lands go in this valley, but the result of poor farming had left its stamp upon the land in soil depletion and inferior crop production.

This we believe is the first attempt in the United States to place an experimental test upon the actual basis of field conditions, except, perhaps, that more pains are taken in the preparation of the soil, in seeding, in irrigation and the various operations involved in seeding and harvesting. An actual measured acre of land was included in each plat, and between these was left a strip three feet wide as a division line and upon which to locate the irrigation ditches between the plats.

The lands were spring plowed and were reduced with spring tooth and Scotch harrow to a perfect state of tilth. Following this was used an implement, which ought to be in use upon every farm in the United States—a land leveller. The one in question was manufactured and patented by Jno. M. Robinson of Bozeman, a practical farmer of many years' experience. Briefly described, it has a platform 8x14 feet supported by three light iron wheels two feet in diameter. These are located one each near the forward fore corners of the platform and the third in the center and at the rear of the platform, the hind wheel having a swivel action, permitting it to swing to either side in turning the leveler.

Four heavy horses are used to draw the leveler, the driver riding on a spring seat over the rear part of the leveler. Hung by springs and operated by a lever is a cutting blade 12 feet by 6 inches, steel shod. This can be elevated and lowered at the will of the driver, and when at the proper cutting angle and in place, *planes off all inequalities in the soil*, carrying the soil thus cut in front of the cutting blade or planer, until ground of a lower level is reached, and upon this the excess soil which has been carried ahead of the blade, is deposited and other unequal ground is sought.

The capacity of the leveler is 25 acres per day upon lands that are moderately uneven; for example: lands which were originally fairly level, but by the injudicious laying off for plowing have accumulated dead and back furrows, etc. In lands that have been irrigated it is very useful in cutting the banks of old ditches to grade, and in filling the ditches proper.

Its use should be employed annually, and it stands to reason that if the surface of the field be brought year by year to a true plane that eventually fields thus manipulated will be in very much better condition for farming.

In irrigable lands many employ a crude home-made leveler, constructed of poles or logs, or a better style is made of 3-inch plank of suitable length spiked together with edges overlapping. These are all useful for clod crushing and soil pulverization, but their value in bringing rough lands to grade is extremely limited. In applying water more time is lost by the faithful irrigator in conducting water onto the knolls and high places which are to be found in any field under common cultivation, than he employs to irrigate the favorably lying areas. Equal distribution of water upon grain fields is most important because there is an uneven ripening of grain receiving in its different parts an uneven application of water—that which is most thoroughly irrigated being the last to ripen and vice versa.

Fields that are thus spotted do not yield as they do when they ripen evenly, for if we wait to harvest until all sorts are ripe there is loss from shelling of grain upon the lands which are first to ripen. Again, should the field be cut before the perfect ripening of the whole has been accomplished, there is a shrinkage of the kernels in the unripe portions and a consequent lowering of grade. So that under irrigation it is especially to be desired that all parts of the field be so mechanically prepared that water may be impartially distributed over the entire area.

Again, in sections where irrigation is not practiced, in the humid sections of the Union, it is obviously harder to control the water supply under natural conditions. It is but seldom that the exact amount of rainfall is precipitated at the exact times to effect the most good to the growing plants. At such times either of a surplusage or a shortage of water, the high lying points and the depressions present in every old field, no matter where situated, receive too great or too small a supply of moisture, the results being about the same in diminishing yields; so that no matter whether one irrigates or depends upon natural rainfall the grading up of the soil to the uniform natural plane is to be desired.

The wear and tear of machinery is also much conserved by having comparatively level fields upon which to operate.

The respective yields of the acre plats were as follows:

Total weight, straw and seed peas	8.085 pounds
Canada field peas	29½ bushels
Barley, Chevalier, two-rowed	48 31-48 bushels
Sugar beets	27,280 pounds
Lincoln oats	55 10-16 bushels
Red clover, sun-cured, dry	1,957 pounds
Spring club wheat	40 57-60 bushels

These are not abnormally good yields for Gallatin County but are good, fair crops, and if our theory be correct that to maintain natural soil fertility, rotation rather than summer fallowing should be practiced, it will work a radical change in Gallatin County farming, first in the increase of lands under cultivation (this on the assumption that lands previously summer fallowed will be cropped under rotation;) second in the character of farm crops produced on Gallatin Valley farms. The first proposition implies more help, more teams, more machinery, more business in fact for the community at large. The second, that there will be crops from a third to a half more in extent to defray the attendant expense of the increased area under cultivation. A farther incontrovertible proposition will be that there will be a smaller per cent of taxation against cultivated lands, as idle lands are not known to the tax-gatherer.

In these yields one crop deserves passing attention, namely, the acre of red clover. This acre was sown in May and was harvested in the latter part of August. In the month of July, without the knowledge of the Director, the mower was run over it to cut off sunflower plants that were beginning to seed. In this operation a considerable per cent of the clover was cut and lost, but, spite of this, the fact that upon an acre of land, within 100 days from seeding, that 1,957 pounds (practically a ton) of well cured hay was harvested, speaks volumes for the adaptation of Gallatin soil to the clover plant.

This 100-day crop will compare quite favorably with the clover meadows of years' standing throughout the Union, and knowing that root development of the clover is co-equal with that of the top, we find in the remarkable vigor of this plant a splendid quality to employ in restoring nitrogen to impoverished lands. If our farmers, pending the time when they could develop ways and means to farm all of their lands under a judicious system of crop rotation, were to sow red clover upon 10, 20 or 40 acres, as the case might be, in the early spring, run live stock thereon after the middle of the summer, and fall plow in good season, they would reap the following season banner crops therefrom, such as would surprise by their magnitude, even a Gallatin County farmer.

In addition to enormous grain production the value of the green food to their live stock, especially dairy cows, would be sufficient to warrant all added expense in connection with the work.

We very much hope to see this experiment tried by some of our progressive farmers in the near future.

STATION FARM CROPS.

The following are the per acre yields upon the Station farm for 1897 :

Barley	50 2-19 bushels
Wheat, spring club	39 6-13 bushels
Oats	48 4-18 bushels
Peas	30 bushels

GALLATIN COUNTY FARM CROPS—1897.

The following are the average yields upon Gallatin County farms for 1897 :

Barley	47 bushels
Spring wheat	37¾ bushels
Winter wheat	38 3-5 bushels
Oats	57¼ bushels
Peas	14 bushels

These yields are again presented in convenient form for comparison, as has been our custom so that our readers (farmers especially) may have opportunity to compare results between open annual farming and summer fallow farming. With the one exception of oats, the Station crop yields are a considerable per cent the better, as follows :

In the case of barley	3 2-19 bushels
In the case of spring wheat	1 37-52 bushels
In the case of peas	16 bushels

While in oats the county yield is $8\frac{35}{36}$ bushels per acre better than the Station farm yield, We think this is a favorable comparison and a good argument against summer fallowing. In the case of the yield of oats it is but fair to state that we have a few acres of very poor land, light and gravelly, and it has been our custom to sow oats thereon. We cannot, of course, expect normal yields under such circumstances, and it is but fair to the annual cropping system to bear this in mind. We continue to use pea land (i. e., land on which peas grew the previous year,) for barley ground. We attribute to this the uniformly better barley crops that are grown on these grounds than that of the county at large. The effects of the nitrogen in the soil placed there by the field pea crops is manifest almost as soon as the crop is out of the ground in the spring.

Unquestionably the plant is of unusual vigor and so marked is this difference that we are able uniformly to irrigate from ten days to two weeks ahead of our neighbors who are mainly producing barley upon summer fallow land. This is a notable difference and is worth much to one who owns an inadequate supply of water, as the difference in the flow of water in mountain streams in ten days is often from one-fourth to one-half less as the season of irrigating progresses. Nor does the barley grown on pea land seem to fall down and lodge as it does on summer fallow land. The straw is stiff and strong and yet not so abnormally large as to carry with its weight an element of weakness. The heads on such straw seem to be of good length with plump, heavy kernels.

Winter stock feeding in Montana valleys is rapidly assuming large proportions. Five hundred thousand head of sheep are being fed in Colorado for eastern markets and there is no good reason why quite as many could not be profitably fed in Montana.

The Yellowstone valley is at present the greatest field of sheep feeding activity in Montana. The leading article of food there used in winter sheep feeding is alfalfa and splendid results are being experienced. Gallatin valley in some ways has superior advantages to other valleys. It is higher, cold weather is more uniform (it is a well known fact that cattle and sheep feed to better advantage in cold than in mild weather) and quite as many tons of clover may be here grown as can be produced elsewhere from alfalfa meadows. A few years' winter feeding of clover to sheep upon Gallatin farms would change not only the character of the farms but that of the bank accounts of the farmers as well. This cannot be profitably done until provision is made for the forage, and this will be encompassed when the idle summer fallow lands are covered with a lush rank growth of clover and alsike.

Winter feeding of cattle and sheep *must come in* and *summer fallowing go out* before the full measure of profit from Montana farms is enjoyed by the owners. S. M. EMERY, Director.

Botanist Report No. 1.

S. M. Emery, Director, Montana Experiment Station :

DEAR SIR—The work of the Botanist has been greatly hampered by the lack of suitable quarters for work. This lack appears in a fair way to be supplied when the alterations in the rooms at the Experiment Station building are finished.

The available time of the Botanist has been taken up largely with herbarium work, as it was felt that the proper ordering of the herbarium was a necessary foundation for future work. The chaos of unnamed collections has been reduced to a system and the plants have been determined as far as possible. The collection of Montana flowering plants is now being compared with the standard herbarium of Columbia University by Dr. P. A. Rydberg, of New York City. This will place the collection in an authoritative position and greatly facilitate future work.

A preliminary study has been made, in conjunction with Dr. Wilcox, of the freezing of fruit trees, with especial reference to the time when the injuries take place. Some clear evidence has been gained on this question, and it is proposed to use these results as a guide to more exact work next year.

A beginning has been made in the field observation, collection and microscopic study of parasitic fungi, causing plant diseases, the intention being to make as complete a study of the plant diseases prevalent in Montana as possible, both from a scientific standpoint and in the case of pests infesting economic plants with a view to remedial measures.

Experiments on the killing of strawberries by frost, and on the self sterility of varieties of strawberries are in preparation for this spring.

Respectfully,

H. S. JENNINGS, Botanist.

Botanist Report No. 2.

Bozeman, Montana, Nov. 24, 1897.

Since my appointment to the Chair of Botany in the Agricultural College in September of the present year, my work for the Experiment Station has been along two lines.

1. An investigation of the winter-killing of fruit trees, with especial reference to the time when the injuries take place. The question for determination is, whether the occasional killing of fruit trees by the Montana winters is an effect of the first frosts when the trees are still growing and unprepared for a freeze, or whether the injuries are due to the intense cold in the dead of winter, or some third alternative. A second object of the investigation is to determine the exact nature of the injuries produced, the ultimate aim being, of course, the discovery of some protective measures. With these questions in view the investigation takes the following form :

An examination of the histological structure of the wood before and after such periods of cold as seem sufficient to injure the fruit trees, to determine the nature and extent of the injuries caused. This examination has been carried to a certain extent for several varieties, both those which have shown themselves hardy and those which have not, being included, with the result of showing that in certain varieties the early frosts, coming when the trees are growing, causes severe lesions in the green living parts. In some cases these lesions are so extensive that it appears probable that they must result in permanent injuries to the trees. Nevertheless it is well known that many trees show a remarkable power of recovery from such lesions, so that positive conclusions can be drawn from these observations only in connection with the observed condition and growth of the trees in the following spring.

Therefore, a second part of the investigation consists in careful observation of the later growth and health of the trees studied, as well as a record of the gross appearance and symptoms of injury during the winter. To put the investigation on a thoroughly experimental basis trees must be taken up and protected after the early frosts and their condition compared with that of trees subjected to the severest coldof winter. This has been done.

Suggested protective measures to be tested also, but probably little can be done in this line until the time and the precise nature of the injuries caused are ascertained. Stripping the leaves from the trees in the early fall has been tried in a number of cases, the results to be noted in the spring.

2. The other line of work, to which I have devoted most of my time when free from College duties, is that in the herbarium. This

is in an absolutely chaotic condition. Large collections of plants have been added in the past few years. but entirely undetermined, and often without the localities or collectors named. To determine and arrange these plants in such a way as to make them of value for reference will require a very large amount of time and labor. Besides the plants belonging to the College or Station, large collections have been sent in for identification, some of them as much as two years ago, remaining still undetermined. These consist in some cases of rare plants unrepresented among the comparatively few already identified in our herbarium. I am attempting to determine such collections and get them off our hands as soon as possible, but in view of the present state of the herbarium and the incompleteness with which the Montana Flora has been studied, this is also a matter requiring much time.

Respectfully,

H. S. JENNINGS, Station Botanist.

Report of Biologist.

As biologist to the Station I would beg to submit the following report for the year ending June 30, 1898:

During the season notes have been made on the important bee plants available for bee culture in the state. These notes are to be worked up in bulletin form in the near future. It has been found that there is an abundance of excellent bee-plants throughout the greater part of the state.

An experiment was carried out on the prevention of potato-scab. Sulphur, Gypsum, corrosive-sublimate and formalin were tried. The results indicated the decided superiority of the formalin treatment.

At the suggestion of the Director we began an investigation of the cause of the bleeding of cottonwood trees. It was found that by washing the wounds on such trees with a rather strong solution of carbolic acid the bleeding could be stopped. The hypothesis upon which we are working is that the sap of these trees is lacking in the antiseptic substances which enable wounds on many other species of trees to heal quickly.

The life history of the grain-aphis was followed from summer through the winter until spring. The grain-aphis was found to hibernate on the roots of fall wheat. Some of the enemies of the aphis were noticed hibernating in the same situation. The results' of this study has been prepared for publication as a bulletin.

The formalin treatment was tried for the prevention of oat-smut. The results will be made known later.

We made a trip to Missoula and the Bitter Root to investigate an outbreak of an army cut-worm. Two methods of preventing its ravages were tried with good success, one consisting in the use of poisoned bait, and the other being the use of water in irrigation ditches. This matter is being prepared in bulletin form.

An outbreak of grasshoppers in Plains valley was investigated and the method of burning the young grasshoppers under straw was tried with good results.

Besides the Bulletin on "Larkspur Poisoning of Sheep," we have published several papers on entomology and related subjects.

Respectfully submitted,

E. V. Wilcox, Biologist.

Report of Chemist.

Bozeman, Montana, June 30, 1898.

Mr. S. M. Emery, Director Montana Experiment Station:

Dear Sir—I herewith submit my report for the past year: There has been a much more general co-operation on the part of the farmers in the sugar beet work than in preceding years, and as a result of this we are able to report on several localities from which previously no samples have been sent.

The results of previous years have been supported by this year's work and serve to emphasize the fact that Montana can produce sugar beets of high grade and purity.

The general average of the beets grown on the Experiment Station farm was $17\frac{1}{10}$ per cent. sucrose in the juice, with a purity coefficient of $81\frac{9}{10}$ per cent. A sample taken from the Farm as early as August 21 contained $19\frac{2}{10}$ per cent. of sugar in juice, and had a purity of 82.8 per cent. These samples were small, however, averaging at this time only $7\frac{6}{10}$ ounces.

The results from localities were as follows:

Locality.	Sugar in Juice. Per cent.	Purity. Per cent.
Gallatin Valley	14.4	76.4
Livingston	14.5	74.3
Kalispell	14.1	76.2
Missoula	12.6	73.6

A recent summary of results in various other states gives the following averages of sugar in the beet and of purity:

State.	Sugar in Juice. Per cent.	Purity. Per cent.
Indiana	12.3	78.1
Michigan	13.2	86.3
Wisconsin	11.8	76.0
Minnesota	14.2	83.3
Missouri	10.0	64.0
Kansas	10.0	72.3
Nebraska	13.6	81.5
Wyoming	16.2	80.9
Oregon	13.2	79.5
Washington	15.2	83.8
Arizona	11.8	73.6

A comparison of these figures with the results of the Montana tests are certainly very favorable to the latter.

The work on the determination of starch carried on in the laboratory in conjunction with other chemists has resulted in decided improvements in the analytical methods applied to the determination of the starches, sugar and their allies, and we have selected after many experiments a method which we think will give much more satisfactory results than those previously in use.

The analysis of irrigation waters was interfered with by unexpected conditions arising in connection with the collection of samples. It is hoped we will be able to continue this work the coming season without interruption.

Much time was spent in moving into our new laboratory and arranging apparatus and material in permanent position. The laboratory is very commodious and convenient and will increase our capacity for analytical work greatly.

Now that we are in permanent quarters, the work on the effects of saline solution upon plant life can continue.

While attending Farmers' Institute, and since, we have had an opportunity to observe the serious effects of alkali in several portions of the State, and have entered into a study of its extent, effects and treatment.

The alkali is much more widely spread than was thought, but its serious effects are noticed in only a few places. A bulletin will be ready for publication after the analysis of next season's samples is complete.

The usual amount of miscellaneous work has been done.

More and more of Mr. Cobleigh's time has been devoted to the work in the Experiment Station laboratory until now he gives almost his entire time to this service, doing nearly all the analytical work, which is constantly increasing in volume and variety.

Yours Truly, F. W. Traphagen, Chemist.

Report of Agriculturist.

To S. M. Emery, Director:

I herewith submit the following report of the werk in the Agricultural and Irrigation Engineering departments :

The season of 1897 was unusually favorable to vegetation and the yields of vegetation from all crops were large. The following experiments were conducted during the past season :

Quantity tests of grain to determine the amount of seed to sow to secure maximum returns.

Variety tests of grains, peas, grasses and potatoes.

Small plats of grain sown to purify and improve seed.

Crop Rotation—A six years' rotation consisting of wheat, clover, barley, roots, oats and peas.

General crop experiments.

Live Stock—The swine have been subjected to experiment to determine the cost of raising swine in Montana.

Bees.—Two colonies of Italian bees were purchased by the Station. The bees thrived. One of the colonies cast a swarm, thus increasing the colonies to three ; 105½ pounds of surplus honey was secured, which is an excellent result.

Irrigation.—The amount of water applied to various crops on the Station farm was determined by means of weirs and water-registering instruments. The crop yield was noted to give an additional index of the time of application and amount of water necessary to produce maximum yields.

Notes were taken on the various irrigation tools and appliances used by the irrigator and the methods used by the farmer in the application of water to crops.

The measurement of various rivers of Montana was conducted during the season.

Respectfully submitted,
Frank Beach,
Agriculturist and Irrigation Engineer.

M92b

BULLETIN NO. 21.

UNIV. OF MICH.
JAN 18 1909

Montana
Agricultural
Experiment Station

......OF......

THE MONTANA COLLEGE OF AGRICULTURE.

Sheep Feeding.

BOZEMAN, MONTANA, MAY, 1899.

ROCKY MOUNTAIN HUSBANDMAN
White Sulphur Springs,
MONTANA.

Montana Agricultural
EXPERIMENT STATION.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman.
Peter Koch, Secretary and Treasurer	Bozeman.
George Kinkel, Jr., Vice-President	Manhattan
Walter S. Hartman	Bozeman
Jno. M. Robinson	Bozeman

EXPERIMENT STATION STAFF.

S. M. Emery,	Director and Horticulturist.
F. W. Traphagen, Ph. D., F. C. S	Chemist.
Robt. S. Shaw, B. S. A.	Agriculturist.
J. W. Blankinship, Ph. D.	Botanist.
R. A. Cooley, B. Sc.	Zoologist.
Samuel Fortier, B. S.	Irrigation Engineer.

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

Montana Experiment Station,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

MONTANA EXPERIMENT STATION.

Bulletin No. 21. *May, 1899.*

Sheep Feeding.

ROBT. S. SHAW.

In Dec. 1898, a number of lambs were purchased by the Montana Experiment Station to be used in making feeding tests, the objects of which were as follows: (1) To determine the possibility of successfully finishing lambs in Montana with the foods here produced and under the conditions now prevailing. (2) To ascertain the amount of food required and the cost of increase under such conditions. (3) To make careful comparison of the relative feeding values of the three legumes—alfalfa, red clover and alsike—as fattening foods. (4) To learn something as regards the actual waste and the economic disposal of the same.

Though large numbers of lambs are annually produced in Montana only a very small percentage are prepared for slaughter, not even a sufficiency to supply the local demand, and in fact not until recently has the flockmaster's attention been directed toward breeding for improved mutton qualities, a factor which can no longer be neglected, for though wool production alone was the primary object at one time changed conditions require a suitable combination of the capabilities to produce both wool and meat. This is necessary because of the demand in other places for our lambs for feeding purposes, and because th

Montana farmer must ere long profit by engaging in such operations. Thousands of carloads of lambs are annually shipped out of this state in an unfinished condition to be fattened by eastern farmers and others who not only market them in the finished condition at good profit but in some instances ship the dressed article back to be consumed on Montana tables. If this can be done at a profit then why cannot the western farmer reap a handsome profit by supplying this demand directly. To call attention to this fact is one chief object of our work. The objection will of course be raised that the flockmaster could not produce more fodder than would be required simply for the maintenance of his large breeding flocks, and that the use of grain would be entirely out of the question. And though such may be the case yet there are those who are suitably located for so doing. We speak of the farmers of the irrigated valleys who are engaged entirely in the production of hay and grain. Those so engaged would find in winter sheep feeding a profitable employment of time during the winter months and an economical way of disposing of coarse grain products and in such a way as to maintain the fertility of the farm. There is found on every farm, in almost every season, quantities of unmarketable grain, it may be screenings or that which has in some way been damaged, and this cannot be better utilized than in fattening sheep. Foul seeds of screenings do not escape in the process ot mastication and digestion as with other animals. We wish to call attention to the fact that with the means and fodders used only comparatively small quantities of grain would be required, the legumes (clovers) forming such an excellent fattening ration in themselves.

The general use of legumes in feeding would not only mean the development of a great industry, for Montana's valleys cover an enormous area and are exceedingly fertile and productive of legumes to a marvelous degree, but the increased use of these in the rotation with wheat, barley and oats would mean an increase of fertility in a form most suitable to the lands of our irrigated region. Fertilizers would be gathered, fixed and rendered available for succeeding crops in a manner unequalled by other methods, and most sure for while the greater portion of the continent is this season lamenting the total destruction of the clover crop through the severity of the past winter, still Montana's valleys are rejoicing in the prospect of an abundance of alfalfa and red clover.

Because of the great possibilities for mutton production the objection might be urged that the local demand would not long be able to consume the product, and such would certainly be the case. This difficulty could be easily overcome by shipping to eastern markets after finishing as well as before. True there would be a greater weight and increased cost of transportation, but then there would be a greater return because of the increased weight and finished condition. Gallatin valley alone is capable of finishing hundreds of thousands of lambs each winter and of producing a quality of mutton unexcelled by the use of alfalfa, clover, alsike, oats and peas.

If a systematic method of feeding is carefully followed much less food is actually required for a given gain than is generally anticipated, as enormous losses are often incurred from injudicious feeding. A careful study of the actual amount of food necessary to produce a given result has been made, and the results given are the outcome of the most natural conditions, such as those under which the average farmer may carry on similar operations.

The three legumes—alfalfa, red clover and alsike—were tested with respect to their relative merits as fattening factors, and our most careful attention has been given to this part of the work as all three, and particularly the first two, are fast coming into general use. Alfalfa is already one of the greatest forage and fodder plants in the arid west, is grown in large area, producing enormous yields from its two, three and oftentimes four cuttings each season, while its tenacity and longevity are qualities of importance. The red clover area is constantly increasing with its popularity and usefulness, having as yet merely passed through the experimental stage. Being less permanent than alfalfa and more quickly brought to maturity it fits perfectly into the grain grower's rotation, and is proving a remarkable ability to establish itself quickly and produce two enormous crops each year. Alfalfa has its favorite locations in Montana, and so has red clover, while in some localities both flourish equally well. Alsike has proved to be of more importance as a sheep food than is generally supposed. It cannot, however, enter into competition with the other two as regards productiveness, but excells in the possession of those qualities which render it a specially valuable factor in sheep feeding. We do not believe it should be brought into competition with alfalfa or clover where these thrive well. But we have in mind some tracts upon which alsike is flourishing where the other two have failed. In combination with red clover we have found produced a food excelling that produced from the clover alone, being finer and more edible and nutritious.

A determination of the comparative waste is also taken into account and observations made regarding the most economic disposal of the same. Ordinarily in making feeding tests the attempt is made to feed so closely that there is little need for taking into account the small waste; there is nevertheless always some. Though the feed racks may be cleaned it will be found in small quantity on the floors or among the litter. In this case especial care was exercised to glean every waste stem twice each day for purposes of accurate comparison. In using legumes which are the product of a very luxurious growth a certain proportion is sure to be rejected by the feeding animals, particularly if they are young ones or are being liberally supplied. On a mere maintenance allowance no account would need to be taken of this, but in using a liberal supply such as would be necessary in order to make profitable gains it would amount to a good deal in feeding extensively. This waste would not be so likely to occur in feeding mature animals which were being wintered over, but in handling large bands of lambs some use can be profitably made of the refuse by feeding to other stock.

DURATION OF EXPERIMENT.

The preparatory feeding began on Dec. 21st, 1898, and continued until Jan. 2nd, 1899, when the experiment proper commenced, to continue throughout eighty-four days. Owing to the condition of the lambs at the start it was the intention to run them throughout a longer period. But as the quality attained was sufficiently good the experiment was closed in order to place the lambs on an early eastern market.

ANIMALS USED.

Were lambs of grade Merino type, showing a slight admixture of Cotswold blood, the result of Cotswold bucks used on grade Merino ewes. Upon arrival at the Experiment Station the forty-eight lambs to be used for feeding purposes weighed up with an average of forty-two and one-fifth pounds each. Considering that the lambs were nearly eight months old they were small framed and in poor condition owing in part to a journey of nearly one hundred miles, from the Madison to the East Flathead valley, in a large band and at a time when the ground was deeply covered with snow. They were hauled in sleds from the East Flathead to the Experiment Station, the snow being too deep to admit of driving. As a result the lambs were not in good condition to go on experiment and make the best returns. We wish to emphasize this fact to show that the results obtained have not been derived from a superior quality of material to commence with, and that under the most ordinary conditions the mutton producer should expect much more than is hereafter given.

SURROUNDINGS AND CONDITIONS GOVERNING EXPERIMENT.

The lambs were fed in open yards, the dimensions of which were twenty by thirty-five feet. Sixteen lambs occupied each yard and had constant access to closed pens for protection when necessary. These pens were just sufficiently large enough to afford shelter from storms. Food was supplied in low slat racks constructed from two by four inch scantlings with slats three by one inch placed in an upright but slanting position, and just far enough apart so that the food could be withdrawn but not wasted by pulling out and trampling. Grain was given in shallow troughs raised fifteen inches above the ground. Both pens and yards were kept dry and comfortably bedded.

FOODS.

Those used for comparison were alfalfa, red clover and alsike. Both alfalfa and red clover were from second cuttings, while the alsike was from a first. All three were apparently of equally good quality for their kind. The alfalfa was rather finer of texture than the average and retained both blossoms and foliage. It had been cut when about half the flowers were in bloom, carefully cured in the cock and well preserved in the stack. The red clover used was from a second cutting which had made a remarkably strong, vigorous growth. Of the three fodders it was probably as coarse as any but had been cut in early bloom and all the parts preserved in curing. The alsike was fine of stem and leafy, bright of color, retained the cured blossoms, and as a food stuff possessed a remarkably attractive appearance. According to analysis these foods were found to be of the following composition :

	Alsike. Percent.	Red Clover. Percent.	Alfalfa. Percent.
Water	6.05	5.16	5.09
Crude Protein	13	12.37	12.37
Ether Extract	3.07	5.29	4.07
N. Free Extract	38.71	45.84	39.82
Crude Fibre	29.45	22.65	31.10
Ash	9.72	7.55	8.79

GRAIN.

Consisted chiefly of oats during the first half of the period, but during the second half cracked peas and a small quantity of whole flax seed were added in the quantity and manner hereafter described.

ROOTS.

Turnips were supplied throughout the entire period, not so much as a fattening factor as for the beneficial influences which would be brought to bear on the digestion and general tone of the animals.

FEEDING.

During the preparatory feeding only those foods were used which were to be continued throughout the experiment. For the twelve days covering this period the following amount of food was given: Of the three hays, 1.87 lbs. per head was consumed each day, while thirty-six pounds of oats was supplied to each lot during the period. Throughout this short period only a very small gain was made, amounting to one and eight-tenths pounds per head, but the lambs became accustomed to the food and somewhat adapted to the new conditions. With lambs brought from the range, as these were, a lapse of time is essential for adjustment to the food and surroundings before good gains can be made. Quite an appreciable manifestation of uneasiness was noticed during the first few days despite the efforts to preserve quiet and promote comfort. As it was the desire rather to make a comparison between the fodders only a very small grain allowance was used. The quantity to begin with on Jan. 2nd was one-quarter pound oats per head per day, which was gradually increased, by additions each week, to three quarters of a pound at the end of six weeks or one-half the period. No farther increase of oats was made throughout the experiment. Beginning with the seventh week an ounce of flax seed per head per day was added and continued throughout the test. Flax seed was fed in this form because of the difficulty and expense of obtaining nutted oilcake or linseed meal; it was nevertheless completely consumed and perfectly digested. In addition to the oats and small amount of flax seed used, cracked peas (pea screenings) were added at the beginning of the eighth week and gradually increased to three-quarters of a pound by the beginning of the twelfth or last week. The grain supply thus reached a limit of one and one-half pounds per head per day, plus the flax seed, with an average of three-quarters of a pound throughout the test.

It will be noticed that the grain ration was a light one and that the additions and increases were made very gradually. Figuring upon the basis of composition given the nutritive rates at the commencement of period was about 1:55, which was narrowed to 1:45 as the finishing period approached. We believe as a result of this method a saving of food is effected and the animals are maintained in a much more thrifty condition. Throughout the whole period of eighty-four days no losses occurred from death among the forty-eight lambs under experiment, and in no case did any constitutional disturbances occur except slight recurrence of bloating among the alfalfa lot. We believe it to be an important factor in lamb feeding never to supply a greater amount of food than can be properly eaten and digested. Once gorged a lamb will never again regain its former possibilities.

The grain, hay and roots were all three fed twice each day. The hays were fed to the three lots in as nearly equal quantity as their capacity would allow. Roots were pulped and fed along with the grain ration. As regards the time of feeding, the morning feed was given about 7 a. m., and the afternoon feed from 4 to 4:30 p. m. An attempt was made to widen this period by feeding one hour later in the evening but with approaching darkness if severely cold and windy the lambs would leave the feed yards before entirely consuming the food.

Water was supplied each day just after the noon hour and it was noticed that notwithstanding this fact snow would be consumed so long as any was to be found in the yards. The necessity for a constant supply of good, pure water was strongly manifest. The lambs refused to drink from a stream where other stock was accustomed to go.

Salt was supplied in such a way that the lambs had constant access to it.

FOOD CONSUMED.

In case of the grain and roots these were fed in equal amount to all three lots. The fodders supplied were also practically the same, but in the tables a slight difference will be noticed because of variation in the texture and edibility of the three foods. In the following table the actual amount of food consumed by each lot of sixteen lambs during the eighty-four days is given:

	Hay. Lbs.	Roots. Lbs.	Oats. Lbs.	Peas. Lbs.	Flax. Lbs.
Lot I. On Alsike.........	2562	1840	780	241	42
Lot II. On Red Clover....	2588	1840	780	241	42
Lot III. On Alfalfa	2484	1840	780	241	42

The results from the food consumed are as follows:

Lot I. fed alsike, made a total gain of 405 lbs.
Lot II. fed red clover, made a total gain of 402 lbs.
Lot III. fed alfalfa, made a total gain of 377 lbs.

In dividing the lambs up into lots as uniform a division was made as possible as regards weight, quality and breeding. At the beginning the greatest difference in weight between any two lots did not exceed 12 pounds. With the gain and amount of food given, by placing a valuation on the food consumed some interesting data are reached. The prices placed upon food are those of the local market at the time the food was consumed and are as follows:

Oats, $1.00 per hundred weight.
Pea screening, 50 cents per cwt.
Flax seed, $1.50 per cwt.
Hay, $6.00 per ton.
Roots, 9 cents per cwt., or cost of production.

Computations upon the basis already given show the following results:

LOT I—ALSIKE.

Alsike consumed per pound gain........................	6.32 pounds
Grain consumed per pound gain........................	2.02 pounds
Average amount of alsike consumed per head per day...	1.9 pounds
Grain consumed per head per day......................	.79 pounds
Gain per head per month of thirty days	9.04 pounds
Cost per pound of increase............................	4.51 cents

LOT II—RED CLOVER.

Red clover consumed per pound gain	6.48 pounds
Grain consumed per pound gain	2.04 pounds
Hay consumed per head per day	1.92 pounds
Grain consumed per head per day	.79 pounds
Gain per month of thirty days (per head)	8 07 pounds
Cost per pound of increase	4.62 cents

LOT III—ALFALFA.

Alfalfa consumed per pound increase	6.58 pounds
Grain consumed per pound increase	2.81 pounds
Alfalfa consumed per head per day	1.84 pounds
Grain consumed per head per day	.79 pounds
Gain per head per month of thirty days	8.41 pounds
Cost per pound of increase	4.84 cents

The gains per pound as given would cnly be very moderate for a good quality of well bred lambs. These were, however, small for their age and unthrifty, consequently the gains were somewhat slow, requiring a large amount of dry matter per pound increase. It will be noticed from the results that the lambs fed on alsike gave slightly the best returns in every respect, with red clover a close second, while alfalfa comes third with only a slight difference. In the case of both alsike and red clover the progress of lambs was most satisfactory. In Lot III, fed on alfalfa, symptoms of bloating occurred several times, despite the fact that the utmost care was exercised in supplying and increasing their food judiciously. No serious disturbance occurred except in one case where the lamb had to be punctured with trochar and treated. As the lamb did not thrive as the others throughout the remainder of the period it was withdrawn at the close of the test and calculations based on the remaining fifteen.

Though in this test alfalfa has not headed the list, it is still not far behind, and it must be remembered that this is a test not as yet duplicated under similar conditions. Then we wish to call attention to the fact that though the quality was apparently first class, chemical analysis ha sshown it to be somewhat lower in protein than the average. It is nevertheless a great forage and fodder plant throughout the arid west and will doubtless always occupy an important place as a stock food. We do not wish to decry, it for it thrives in many sections of Montana, producing abundantly where the other clovers do not do so well.

Red clover gave pre-eminently good satisfaction throughout the test, which was especially noticeable in the feeding yards. Though alsike gave such good returns it cannot occupy the same wide range of usefulness as the other two, being a smaller producer and more difficult to cut and cure when grown alone. Alsike, however, produces phenomenally under irrigation and may be grown under conditions not suited to the other two. Mixed with red clover it improves the quality of the same, while for permanent pasture it affords an abundance of food, providing some water is supplied. It withstands freezing well also.

As regards the refuse material some data was gathered concerning the relative amounts from each and the economic disposal of the same. Though the desire was to feed as closely as possible, there were still some leavings, consisting of coarse, woody, inedible stems. Generally speaking, it is not desirable that there should be such. With mature animals on a maintenance diet there would not be. But under the conditions stated, with liberal feeding, small quantities will remain uneaten. The actual amount of refuse was determined as follows: Alfalfa, 15%, red clover, 13% and alsike, 11%. Where feeding for fattening purposes is carried out on a large scale the question of the economic disposal of refuse is an important one. The impression prevails that neither cattle nor horses will consume the leavings after sheep, but not a few extensive feeders use this refuse in the maintenance of cattle. It must of course be removed each day and will necessitate the use of clean, dry feed yards. The refuse material was in this instance fed to both cattle and horses confined in a stack yard with a good supply of both pea and oat straw. Almost without exception the red clover refuse was entirely consumed by them first, then the alsike and lastly, and often uncompletely, the alfalfa straw.

The question of size and quality of carcass necessary to exactly suit the demand was made a subject of investigation. As already stated, the lambs used in this test were light at the start and though they dressed out at the rate of fifty per cent, which gave a carcass of forty pounds weight, it was found on placing these upon the local market that they were too small and would have handled more profitably to both feeder and retailer had they dressed at least ten to fifteen pounds heavier. These lambs brought a return of ten cents per pound dressed weight on going into the hands of the retailer. As regards quality this is a matter of great importance. Excessively fat mutton is not in demand, but a moderately fat carcass, well intermixed, fine of texture, juicy and tender, is increasing in demand. To attain such results should be an easy matter to the Montana farmer with his nicely blended food factors as found in the legumes, grains and roots already described.

The chief object being to make a food test, no financial record is given and such will probably be made the leading factor in succeeding trials. The lambs were purchased in a band along with breeding stocks, consequently an estimated rather than an actual valuation would necessarily have to be placed upon them. With the statistics given, however, a very fair idea can be formed as to the profits from feeding lambs for local markets.

SUMMARY.

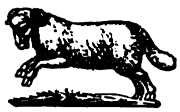
(1) With the great abundance of leguminous crops and the ease with which they can be produced in Montana, we believe it would be of great advantage to the Montana farmer to fatten at least a few sheep each winter season.

(2) Under the very favorable climatic conditions the amount of food required and cost of production per pound gain are relatively small.

(3) Careful comparison has shown that alsike, the red clovers and alfalfa have given results for feeding value in the order named.

(4) That food materials which would otherwise be wasted can be utilized with profit where sheep are kept on the average farm.

Thanks are due Dr. Traphagen who kindly furnished the analyses of the foodstuffs used.



630.679
M19eb

UNIV. OF MICH.

BULLETIN NO. 22.

Montana
Agricultural
Experiment Station

......OF......

THE MONTANA COLLEGE OF AGRICULTURE.

THE RESISTANCE OF STRAWBERRIES TO FROST.
POTATO SCAB.
TREATMENT OF SEED OATS FOR SMUT.
LOSSES CAUSED BY THE GRAIN APHIS.
ROUP OF CHICKENS.
THE INTERNAL CHICKEN MITE.
LUPINES AS PLANTS POISONOUS TO STOCK.
CATTLE POISONING BY THE TALL LARKSPUR.
POISONING OF STOCK BY THE WATER HEMLOCK.
ERGOTISM IN HORSES.
THE POISONING OF CATTLE BY SMUTTY OAT HAY.
LIST OF PLANTS OF KNOWN OR SUSPECTED POISONOUS PROPERTIES WHICH OCCUR WITHIN THE STATE.
SOME NATIVE FORAGE PLANTS OF THE STATE.

By E. V. WILCOX, Ph. D.

BOZEMAN, MONTANA, JUNE, 1899.

ROCKY MOUNTAIN HUSBANDMAN
White Sulphur Springs,
MONTANA.

Montana Agricultural
EXPERIMENT STATION.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman.
Peter Koch, Secretary and Treasurer	Bozeman.
George Kinkel, Jr., Vice-President	Manhattan
Walter S. Hartman	Bozeman
Jno. M. Robinson	Bozeman

EXPERIMENT STATION STAFF.

S. M. Emery,	Director and Horticulturist.
F. W. Traphagen, Ph. D., F. C. S	Chemist.
Robt. S. Shaw, B. S. A.	Agriculturist.
J. W. Blankinship, Ph. D	Botanist.
R. A. Cooley, B. Sc.	Zoologist.
Samuel Fortier, B. S.	Irrigation Engineer.

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

Montana Experiment Station,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

MONTANA EXPERIMENT STATION.

Bulletin No. 22. **June, 1899.**

The Resistance of Strawberries to Frost, And Twelve Other Subjects.

By E. V. Wilcox, Ph. D.,
Formerly Biologist of Montana Experiment Station, now Assistant Entomologist to the Department of Agriculture, Washington, D. C.

As is well known to strawberry raisers, a light frost often occurs in late spring killing a small proportion of the flowers and young fruit of the strawberry. Injury from such frost is readily recognized in the blackening of the pistils within a few hours after the frost.

In Bulletin 16 of the Station, Director Emery made a report on the effects of a white frost which occurred on June 11, 1897. On June 21 examination was made to determine the extent of damage from this frost. A tabulated statement is presented in Bulletin 16 showing the percentage of injury in 58 varieties. The average amount of injury for all varieties which were affected by the frost was 4 per cent., and the extent of damage in different varieties varied from 0 to 12 per cent. The following nine varieties escaped all injury from frost: Bisel, Crescent, General Putnam, Princeton Chief, Parker Earle, Robinson, Stevens, Shuster Gem and Warfield.

As indicated by Director Emery, the varieties in this list are all late bloomers with the exception of the Warfield, which is one of the earliest bloomers. Among the varieties which suffered most, mention should be made of the Columbian, Muskingum, Tennessee, Governor Hoard and Michel Early.

These observations were placed at the disposal of the writer by Director Emery, with the suggestion that an investigation of the matter be made. A study of the problem was at once begun, with the results which are outlined in the present account. No frost occurred during the flowering season of strawberries in 1898, and it was, therefore, impossible to verify the results by further observations.

For the purposes of this account it is not necessary to descrfbe the structure of the strawberry flower and fruit in any great detail. It is merely to be remembered that the pulpy portion of the fruit of the strawberry, which is known to botanists as the receptacle or torus, constitutes the edible material of the fruit. Imbedded in this receptacle in pits of varying depths are the seeds or achenes scattered over the surface of the fruit.

The method of study which was adopted in this investigation may be very briefly described. Young fruits of various varieties were collected and hardened in various preserving fluids and finally sectioned with a razor and subjected to microscopic study. Besides a study of the fruit. which was conducted in the manner just indicated, some attention was given to the immature stamens and pistils of flowers which had just opened.

It was found that in a number of varieties the anthers were injured by the frost. No comparison was made to determine the relative susceptibility to frost of anthers of different varieties, since such comparison did not promise any valuable results. The injury to the anthers consisted in rupture of the tissue in which the pollen grains were imbedded and in the killing of a small proportion of the pollen grains. In unfertilized flowers it was noticed that some injury had been produced in the styles and stigmas, so that these organs were probably no longer capable of receiving the pollen grains and transmitting the pollen tube.

The attention of the writer was chiefly directed to a study of the injury from frost in young berries which had begun development and had attained various sizes up to that of a pea. In such fruits the general statement may be made that the injury was confined to the achenes or seeds of the strawberry. The pulpy mass or receptacle was in no case injured to the slightest extent. The surface of the receptacle did not blacken and its tissues did not show any rupture or other change which could lead one to suppose that it had sustained any injury from the frost. The achenes, however, in the varieties which suffered injury were killed by the action of the frost, and rapidly exhibited discoloration and decomposition of their tissues.

The problem which was had in mind during this study may be stated as follows : Are there any demonstrable anatomical differences in the structure of the fruits of different varieties of strawberries which would account for the physiological differences. For the striking difference in the power of resistance to frost on the part of the different varieties of strawberries make it apparent that there is a physiological difference in these varieties, and it was the purpose, therefore, of the present study to determine whether there was any recognizable anatomical difference in structure which correspond to the conditions of the case.

It was found upon a study of the structure of injured and uninjured strawberries of different varieties at the same immature stages of development that in those varieties which did not suffer from the frost, the achenes were more deeply imbedded in the substance of the receptacle than was the case in those varieties which were most injured by frost. In this connection it should be remembered that the growth and development of the receptacle, or, in other words, the growth of what is commonly thought of as the strawberry, depends largely upon a stimulus which the receptacle derives from the presence of living achenes on its surface. If these seeds or achenes are not fertilized in the ordinary manner, the growth of the receptacle does not take place; in other words, the strawberry does not develop. This fact is strikingly illustrated in cases of partial fertilization where some of the achenes are fertilized and others not. In such cases the receptacle underneath the achenes which are fertilized develops, while other portions of the receptacle, upon which the unfertilized achenes rest, do not develop, and the result is a onesided or unsymmetrical strawberry. A similar result is brought about by the killing of the achenes from frost after they have once become fertilized. After their fertilization, development begins immediately, but as soon as they are killed by frost or otherwise, the growth of the receptacle ceases and the young fruit finally shrivels up.

The seed of the strawberry is anatropus, that is, bent back completely upon itself so that the style or free end of the pistil seems to arise from the base of the seed. The style is probably the most delicate and easily injured portion of the pistil, but when once fertilization has taken place, its function has been performed and it is henceforth useless to the strawberry. The preservation of the life of the seed, however, as just indicated, is necessary to the further growth of the strawberry fruit.

In those varieties in which the achenes were so deeply imbedded in the receptacle that they were protected from the frost, the protruding styles were killed by the frost as completely as in the case of the varieties where the seeds were also killed. It was noticed, however, that although the surface of the berry at this time exhibited the blackened tips of the styles, the fruit proceeded with its development and ultimately all trace of injury was obliterated.

An examination of numerous sections of berries which were injured by the frost demonstrated also a slight variation in the thickness of the seed coats in different varieties. This variation in the thickness of the seed coats seemed to be quite independent of the variation in depth to which the seeds were imbedded in the receptacle. This variation, however, was not a phenomenon of so regular occurrence that it could be assumed to be of prime importance. So far as these studies indicated, it seemed necessary to conclude that the chief cause of variation in the susceptibility to frost was in the varying amount of protection furnished to the achenes by the surrounding pulp.

In the varieties already named as being most damaged by frost, the achenes were most exposed upon the surface and they were least exposed in those varieties which suffered least. In general it may be said that a tolerably regular series of gradations was found to prevail, running from the varieties which were uninjured by the frost to those which were most damaged. Aside from this condition of anatomical structure, nothing of an anatomical nature was discovered which could be considered as a factor in the determination of the difference in the susceptibility to frost. It is, however, not safe to conclude that this one variation in anatomical structure is the only factor in the case. Many instances might be mentioned of physiological differences in the varieties of the different species without any noticeable corresponding anatomical difference, and it would not be unreasonable to suppose that noticeable physiological changes might be the result of anatomical changes which were as yet too little pronounced to be recognized with certainty.

Further study of the susceptibility to frost of different varieties of strawberries may develop other determining factors, but until such discoveries are made we may reasonably believe that the one mentioned in this account is of considerable importance in the biology of the strawberry. Mention has already been made of those varieties which were not injured by the frost and a few varieties were named which were most injured by the frost. These latter varieties were named in the regular order of the relative amount of injury, beginning with the Columbian where the injury was greatest.

This account may be briefly summarized as follows: A striking difference in the amount of injury from frost was noticed in different varieties of strawberries. Upon examination of sections of the fruit of these different varieties it was found that in those varieties in which the injury was greatest the seeds were most exposed or were situated in very shallow depressions of the strawberry pulp. On the other hand, in those varieties which did not suffer from the frost, the seeds were protected by being imbedded so deeply in pits of the plant that they were practically surrounded by the pulp. Between these two extremes there was found a regular series of gradations represented by varieties in which the seeds were imbedded in pits in the pulp of varying depth.

Potato Scab.

Among potato diseases which possess economic significance, potato scab occupies a prominent place. It cannot be considered the most serious enemy of the potato, but its distribution is nearly coextensive with the potato. The disease has been referred by different authors to a number of causes, among which may be mentioned, animal parasites, vegetable parasites, excessive moisture, mechanical irritation, the action of chemical substances and of manures. A number of fungi and bacteria have been supposed to cause the disease, and the bacterial origin of potato scab has been upheld with considerable persistence. Dr. Thaxter, while connected with the agricultural experiment station of Connecticut, made a thorough study of the nature and cause of the disease and discovered the vegetable parasite which is responsible for potato scab, This was found in the form of one of the lower fungi and named *Oospora scabies.*

The general appearance of potato scab is too familiar to require any elaborate description for its recognition. Usually in examples of the disease which were studied at the station, its first appearance was in the form of slight swellings at various points. These swellings became more and more prominent until the epidermis was ruptured upon the convex surface. The subsequent action of bacteria which are allowed to enter the tissues of the potato brings about a decomposition of tissue until the scab ultimately assumes a form of depression or excavation. During the process which has just been described, there is usually noticeable a deepening of the pigment found immediately under the outer skin of the potato. The color of the skin at these points becomes much more pronounced. Along with these processes there is also to be observed a progressive destruction of the starch and other food materials immediately under the scab areas. Even previous to the rupture of the epidermis, the absence of starch in those portions of the potato tissue which lie directly underneath the scab patches is very striking.

Aside from the disfiguration of the potato and the consequent depreciation in its market value, the scab produces very little real loss in the potato. the destruction of starch and other nutrient substances being confined to the superficial tissues.

Two forms of potato scab have been distinguished, the superficial and the deep forms. These forms, however, apparently do not differ in any essential manner except that the deep form is a more advanced stage of the disease, After the disease has once become established, the depth to which it penetrates seems to depend largely upon the soil conditions to which the potato is submitted. If potatoes are dug as soon as mature, or even at an earlier date than would seem advisable for healthy potatoes, the progress of the scab is arrested. If, however, the potatoes are allowed to remain in the ground until late in the fall the disease progresses and the scab areas become deep-seated.

An experiment was conducted at the station for the purpose of determining the value of certain substances in preventing potato scab. Seed potatoes were secured which were exceedingly scabby, and these potatoes were planted in 5 rows. Row 1 received 1 tablespoonful of gypsum in each hill; row 2, ½ tablespoonful of sulphur in each hill. The potatoes of row 3 were soaked in a solution of corrosive sublimate in the proportion of 2¼ ozs. to 15 gallons of water for 1½ hours. The seed potatoes of row 4 were kept in a solution of formalin in the proportion of 8 ozs, to 50 gallons of water for 2 hours. Row 5 was untreated.

These different substances had, so far as the results showed, no appreciable influence upon the yield of the potatoes. The yield of the two rows which were treated with the corrosive sublimate and formalin was slightly larger than that of the other rows. The potatoes, after being dug, were carefully counted and separated ino two heaps of scabby and healthy potatoes. The percentage of scabby potatoes was as follows : 45, 40, 3, 1, and 50 per cent for rows 1, 2, 3, 4 and 5, respectively. It is thus seen that formalin is a very effective substance in preventing potato scab. It has the further advantage that it is non-poisonous and non-corrosive and may be used either in wooden or metallic vessels.

Treatment of Seed Oats for Smut.

The nature and appearance of smut diseases of various cereals are rather familiar to the ordinary observer, and it is generally well known that the losses in the yield of wheat and oats from these diseases are very extensive. The smut of oats being produced by a parasitic fungus, the spores of which are carried upon the seed oats, the remedies for the prevention of this disease are evidently to be applied to the seed grain.

Of the numerous remedies which have been suggested, a great deal may be said in favor of each one, but nearly all remedies suffer, on the other hand, from certain disadvantages. Blue vitriol is exceedingly corrosive and poisonous, and when used in proportions sufficiently strong to destroy the smut spores, is likely to cause injuries to the seed grain, so that a smaller proportion of the grain will germinate. The hot water treatment, while perfectly effective as a remedy for smut, requires a rather elaborate apparatus for its application and also a considerable amount of time and attention. The overheating of the grain is, of course, fatal to the life of the grain, and, on the other hand, one must be sure that the water is kept at a sufficient temperature to destroy the smut germs upon the seed grain.

An experiment was tried with formalin as a preventive of oat smut, in which this treatment was directly compared with the ordinary treatment with blue vitriol. The seed oats were placed in ordinary gunny sacks and allowed to soak for two hours in a solution of formalin in the proportion of 1 lb. to 50 gals. of water. The oats were then removed and placed upon a canvas, which had been treated with the same solution, and allowed to dry. The ordinary blue vitriol treatment was applied to a portion of the seed oats and the seed was drilled in upon one piece of ground so that the areas which were sown with seed grain treated by these two methods were contiguous. In the oats which developed from the grain treated with blue vitriol the smutty heads were numerous and conspicuous, while among the oats which grew from the seed treated with formalin there were found only two or three smutty heads in about two acres. The difference in the effectiveness of these two treatments was so striking that it could be noticed from a distance.

Formalin, as elsewhere stated, has other advantages besides being more effective than the blue vitriol method. This substance is at present not at all expensive. When formalin first came into prominence its manufacture was not yet perfected to such an extent that it could be sold cheaply, but the field of its application was widened very rapidly until at present the cost of formalin is no obstacle to its use on an extensive scale. The form in which it is ordinarily sold is the gas in solution of water, the strength being 40 per cent. Formalin has been found to be useful not only in the treatment of potato scab and grain smuts, but also in the disinfection of houses, clothing, stables and miscellaneous implements about barns after the prevalence of contagious diseases.

Losses Caused by the Grain Aphis.

The appearance, habits and life history of the grain aphis have already been referred to in Bulletin 17 of this station. The insect has long been recognized as of considerable economic importance. The abundance of the grain aphis varies exceedingly in different years. During some years it occurs in such numbers upon the grain that the crushed bodies of the aphis render greasy the harvesting machine and thus interfere with its operation. Different entomologists have estimated the losses caused by this insect, but these estimates have been made largely from a study of the difference in yield of grains during different years by different farmers.

At the suggestion of Director Emery, the writer undertook to determine, as accurately as possible, the nature and amount of damage caused to wheat by the action of these insects. This study was made during a time of great abundance of the grain aphis. The experiments which are here reported included a considerable number of varieties of wheat and were conducted in the following manner: A number of the heads of each variety of wheat were covered with a netting which prevented the grain aphis from entering. The netting was kept on until the wheat was ripe. One or two days before the wheat was cut, a few of the protected and unprotected heads of each variety were collected and reserved for study. It was found on removing the grains from these heads that the size of the grains from the protected and unprotected heads did not differ to any noticeable degree. Before the grains had been allowed to dry the weight of 100 grains from protected and unprotected heads of any variety was approximately the same. It was, therefore, at first believed that the grain aphis had very little injurious effect upon the weight and the yield of the grain. After the grain had been allowed to dry, however, it was perfectly apparent that the grain aphis had produced serious injuries in the size, appearance and weight of the grains. The grains from the infested heads shriveled up in drying to a much greater extent than did the grains from the uninfected heads, and the weight of grains from infested heads was from 15 to 35 per cent less than the grains from uninfested heads.

A considerable proportion of the grains taken from the infested heads became so shriveled in drying that it was evident that in the ordinary process of threshing they are blown over and are to be found among the screenings. The difference in the appearance of threshed grain is, therefore, no indication of the amount of damage done by the grain aphis since, as just indicated, the grain which is worst damaged is not measured with the threshed grain.

It is evident from this brief account that the damage caused to grain by the prevalence of the grain aphis is very considerable and is probably in the majority of cases even greater than has usually been supposed.

No chemical analyses were made of these different grains and it is, therefore, not possible to state whether the presence of the grain aphis produces any pronounced chemical change in the grain or whether the loss is merely in the appearance and weight of the grains.

Roup of Chickens.

This disease, often also called diphtheritic roup, is recognized as being very similar to the ordinary diphtheria of man. It has been reported in some instances that children have acquired diphtheria by contact with chicken roup, and, on the other hand, that roup among chickens has developed from contagion by diphtheria of man, The investigations which have thus far been conducted have almost uniformly demonstrated that the organism which causes roup differs in certain particulars from that of diphtheria. The differences are not great but the general consensus of opinion is that they are distinct pathogenic organisms. Roup is one of the more important diseases of domestic poultry and attacks the common fowl, turkeys, ducks, pea fowls, pigeons, pheasants, etc. The symptoms of the disease may be briefly described as follows:

Among the first signs of the disease is the presence of diphtheritic patches in the mouth, pharynx, larynx, nostrils and upon the eyes. These patches are of a purulent nature, become hard and firm, and may be removed entire. When removed, however, they leave a bleeding surface. The disease may be confined to the mouth, pharynx and eyes, but often it spreads beyond these parts and invades the trachea, œsophagus, lungs and air sacs.

So long as the disease is confined to the mouth and larynx it may be cured; but once it has infested the trachea or the lungs it is practically impossible to check its progress.

In combatting this disease it should always be remembered that it is contagious and one of the first measures, therefore, to be adopted is the isolation of all affected birds and the thorough disinfectfon of the premises. The disinfection may be accomplished by means of a 5 per cent solution of carbolic acid. All the fowls that die should be either burned or carefully buried in order to prevent the spread of the contagion. The success of the treatment of the disease will depend largely upon the closeness of the watch kept upon the fowls and upon the thoroughness with which applications are made to the diseased parts. The diphtheritic membranes may be readily removed with a small piece of wood, and the mouth, larynx and eyes may then be treated with antiseptic solutions.

Among the substances which have been recommended for this purpose we may mention tincture of iodin, salicylic acid and boric acid. The tincture of iodine is to be applied directly to the surfaces from which the diphtheritic membranes were removed. Salicylic acid in the proportion of one grain to an ounce of water may be used for washing the eyes, and boric acid in the proportion of 15 grains to one ounce of water is a good antiseptic wash for the eyes and mouth. If one wishes to adopt another form of treatment, it is possible to secure roup antitoxin from the firms which sell such substances for vaccinating diseased birds. Roup antitoxin operates in a manner similar to that of diphtheria antitoxin. In fact, it has been claimed that diphtheria antitoxin is a successful remedy for roup. This, however, requires confirmation. Roup antitoxin has been extensively used in Europe and this country with good success.

A treatment which was adopted during an outbreak of roup among the station fowls in Montana gave good results, and we may briefly describe the method as follows: The diphtheritic membranes were first removed from the mouth, larynx or eyes and to the raw surfaces thus exposed in the mouth cavity direct application was made of lunar caustic. The mouth cavity and eyes were then thoroughly washed with a solution of nitrate of silver in the proportion of 8 grains to the ounce of water. This wash was applied by means of a small swab which was of such a size as to allow its introduction into the larynx. In some cases one application of this sort was sufficient. In others two or three had to be made, but it was shown that the remedy may be used successfully in curing roup, provided the disease has not progressed beyond the larynx.

The question as to whether any direct treatment should be adopted for roup is one which will probably be settled in different ways by different poultry raisers. The course of action adopted will probably depend somewhat upon the number of fowls affected and also upon their value. The application of any remedy which involves the removal of the diphtheritic membranes and the use of an antiseptic wash is, of course, a somewhat laborious process and it may be considered by some poultry raisers that where the outbreak of the disease is noticed at its start and only a few fowls are affected, the safest and surest remedy is the destruction and burning of the affected fowls. In any case it will be found desirable to disinfect thoroughly the premises where the outbreak of roup has occurred or, perhaps better still, to remove the poultry to a new location. The pieces of false membrane which form in the mouth are apt to choke the fowls and cause coughing. They will thus be thrown out on the ground and are likely to be eaten by the other fowls. It is absolutely necessary, therefore, in preventing the spread of the disease that all infected fowls should be immediately separated from the healthy ones. It is also to be remembered that the bacterial organism which causes the disease may live for a considerable time in pieces of the false membrane which have been thrown out upon the ground, and thorough disinfection is, therefore, necessary even in case no fowls are allowed to inhabit fhe same quarters for some time after the original outbreak:

The roup antitoxin treatment furnishes a sure and complete cure for the disease and other treatments which involve antiseptic washes also give good results, provided they are carefully applied. It may be asserted, therefore, that roup can be readily cured, and the only question left for the determination of the poultryman is the exact method which he may expect to be most effective under his peculiar circumstances.

The Internal Chicken Mite.

The internal chicken mite, *Cytodites nudus*, is probably the only species of mite which lives within the body of the domestic fowl. The cystic fowl mite, *Laminosioptes cysticola*, lives upon the surface of the skin and frequently penetrates into the skin or even into the subcutaneous connective tissues where it may produce miliary tubercles by irritation. There are no records, however, of this mite in the United States, and its appearance and normal situation in fowls serve to distinguish it at once from the internal chicken mite.

The internal chicken mite is of a pale or nearly white color. The body is almost entirely glabrous with only a few hairs in definite positions upon the upper surface of the body. On the second pair of feet there is present a stiff bristle. The legs are composed of five joints and to the terminal joint is attached a sucking disk which may be protruded and retracted within the joint. The snout is blunt and rounded. The length of the female is about 0.56 mm. and of the male about 0.45 mm, The sexes are easily distinguished by the difference in size as well as by the peculiar genital armature of the male. The species is either viviparous or oviparous, but usually viviparous, the young being six-legged when born. The immature six-legged forms may be readily seen in the bodies of the viviparous females.

The internal chicken mite is of sufficient size to be recognized by the naked eye, and in infested fowls is to be seen as small white specks moving about upon the mesenteries and surfaces of the internal organs. This mite has been found in the trachea, lungs, air sacs, hollow bones and everywhere upon the peritoneum within the body cavity. Besides these more common situations of the mite it has been reported present by certain observers, inside of vital organs of the body. Edgar reports its presence in the ventricles of the heart. Holzendorff and Theobald have reported finding the mite inside of yellow nodules which were found in the liver, and Holzendorff has also reported cases where the mite was found in the substance of the kidneys and lungs. These last mentioned positions, however, are probably exceptional for this species of mite. The position in which it is usually found, as already indicated, is upon the peritoneum and the surface of the internal organs and within the various parts of the air passages. Cytodites has been found in nearly all gallinaceous fowls.

As to the effects produced upon fowls by the presence of this mite within the body, great variety of opinion has prevailed. In general it has been believed that the mere presence of the mite in the air-sacs or upon the peritoneum of fowls had no deleterious effect upon the health of the fowls, It has been assumed that in such situations the mites subsist upon serous fluids with which these membranes are naturally moistened, and that no lesions are produced by the mites in the tissues upon the surface of which they live. Zundel believed that the mites under certain circumstances produced enteritis and peritonitis. Megnin reported a few cases in which the trachea was said to have become obstructed by the presence of great numbers of the mite and that death thus resulted by asphyxia. As already indicated, Holzendorff and Theobald reported finding the mites within pathological nodules in the liver and kidneys, and while it is not distinctly maintained that the mites were the primary cause of these nodules, we are led to suppose that such was the belief of these observers. In the cases which were investigated by Edgar, this observer found the immediate cause of the death of the fowls to be acute endocarditis. It was found that large numbers of Cytodites were present in the ventricles of the heart, and they were naturally supposed to have caused the inflammation. Williams also believed that the mites cause the death of fowls in some manner or other, but no evidence is given of any lesion or definite pathological symptoms caused by Cytodites.

The distribution of the mite is a very general one. It has been studied in France, Germany, Italy, Switzerland, England, and the United States, and it is probably to be found in nearly every place where poultry is raised. In the United States it has been reported from a number of localities and has been studied by several observers.

An important problem in connection with the study of this mite has as yet not been definitely settled. This problem concerns the method of the introduction of the mite into the body of the fowls and therefore its transmission from fowl to fowl. The prevalence of Cytodites within the air passages of fowls would suggest at once that its entrance into the body took place through the trachea. From the air-sacs it could most easily make its way through the thin walls of the air-sacs into the body cavity. The presence of the mite in the bood cavity proper renders it necessary to suppose that Cytodites has the power of penetrating animal membranes. The body cavity is completely closed and entrance to it could only be made by means of piercing the peritoneum at one point or another. So far as is known to the writer, Cytodites has never been found in the digestive canal and it seems rather improbable that even if the mites were swallowed with food material, they could penetrate through the walls of the intestine and reach the body cavity by this method.

Cytodites seems to be very poorly adapted to forcing its way through animal membranes or tissues. The movements of the mite are rather clumsy and sluggish, although at times they manifest considerable activity. The feet, as already indicated, are not furnished with hooks or claws and the snout is not sharp or adapted for penetrating animal tissue. It is readily seen, therefore, that the presence of mites within the ventricles of the heart, as reported by Edgar, is entirely unexplained. While there seems to be no good reason for doubting the accuracy of Edgar's observations, it is certainly impossible to understand by what method the mites gain this position in the body. The ability to penetrate the arterial walls would seem to be almost excluded by the anatomy of the mite. Furthermore, it is difficult to understand how the mites, even after they have gained access to the heart, could maintain their position within the ventricles. With no means of holding on to the surface of the membranes except by the terminal suckers of the feet, one would natnrally suppose that the mites would be swept out of the heart in the blood current and that upon arriving at the smaller arterial branches, they would obstruct the circulation and thus cause the death of the fowl. The presence of the mite within nodules of the liver and kidneys is also to be considered a quite exceptional one.

While making a study of this mite, the writer killed and examined about 150 fowls which were diseased and which in general manifested symptoms similar to those which Williams claimed were indicative of infestation by Cytodites. Only five out of this number of fowls were infested with the mite and in each one of these cases the fowl exhibited pathological conditions which were evidently not connected in any sense with Cytodites, but which were quite sufficient to account for the diseased state of the fowls. In the one case the fowl was infested with an unusually large number of intestinal nematodes. In three cases the fowls were badly affected with tapeworm disease of the intestine, or tæniasis. In the remaining case the small intestine exhibited numerous nodules in its walls, these nodules being due to the presence of tapeworms, and besides this tæniasis the hen was affected with generalized tuberculosis, great numbers of nodules being found in the substance of the liver, spleen, and kidneys. No Cytodites were to be found within the nodules either in the walls of the intestine or of the other internal organs. The mites were found crawling about upon the surface of these nodules, but there was no lesion in these surfaces and no indication that Cytodites was directly connected with the production of the nodules.

Quite accidently the writer discovered a great number of the mites in perfectly healthy fowls. Two hens which were bought for food were thoroughly infested with Cytodites. The hens were fat and in excellent condition, although the mesenteries, especially about the stomach and liver, were simply covered with masses of crawling Cytodites.

From the observations which have already been recorded concerning this mite, it is apparent that statements concerning its economic importance must be made under qualifications. As an example of the necessity of these qualifications we need only consider the fact that Williams from a short study which he made of the mite in Montana believed it to be the most common and important enemy of poultry, and even went so far as to state that Cytodites renders impossible, or at least unprofitable, the raising of poultry in the greater part of the State. By virtue of persistant search and with the aid of several poultry raisers, the writer was able to find only five cases of fowls infested with this mite during the three years' time that the mite was under study. In the case of the two healthy hens just referred to, since the mites were present in immense numbers, it seemed necessary to conclude that they had been in the body cavity for a considerable time, probably some months. This being the case, it follows that mites may be present in the body cavity of fowls in large numbers and for a considerable length of time without causing any lesions or diseased conditions whatever, It is, therefore, probable that Cytodites is of no great economic importance in so far as the direct results of its presence in the bodies of fowls is concerned. It is likely, as already indicated, that the mite occurs in nearly all parts of the United States and could undoubtedly be found in many healthy fowls by a close examination. In stating the belief that Cytodites is not economically important, it is not our intention to discredit the work of Holzendorff, Taylor, Edgar, and Theobald, who reported having found the mite imbedded in tissue or inside of vital organs. If these observations were correctly made, Cytodites under those circumstances must certainly cause disease or death, but it is probable that such cases are very exceptional and that Cytodites, when found upon the peritoneum or in the air-sacs of fowls, lives simply upon the serous food of these membranes and causes no direct injury by its presence.

In connection with the infestation of fowls by Cytodites it may be worth while to suggest that perhaps this mite, while not the cause of a specific disease, may be instrumental in carrying pathogenic organisms from fowl to fowl and may thus help to distribute contagious diseases in a manner somewhat similar to that which has been shown to be true of many insects and related Arthropods.

The mites when present in the trachea in considerable numbers, may produce irritation and coughing by the fowls. The Cytodites would thus be thrown out upon the ground and might be eaten by other fowls. In case of an outbreak of a contagious chicken disease, the Cytodites might thus contribute to a considerable extent to the spreading of the disease. It would at any rate seem reasonable to suppose that Cytodites which came from the lungs or air passages of fowls affected with diptheritic roup or avian tuberculosis might readily become the carriers of these diseases. It is probable that the organisms of leukæmia and chicken cholera could be carried in the same way.

In experiments made by the writer, Cytodites did not exhibit much power of resisting desiccation, but it was found that they could live for at least four days outside of the body of fowls, and they were easily kept alive for two days in a normal salt solution. The mites remain alive in the dead body of fowls for at least 24 hours, and in case these bodies were eaten by other fowls, the mite would be transmitted to these other fowls.

The systematic position and the anatomical character of Cytodites have been so thoroughly discussed by European writers on the subject that it hardly seems advisable to add anything in this line.

As a remedial measures which should be adopted with reference to this mite, it should be stated that no direct remedy could have any effect in removing the mites from the body of the fowls and, as already indicated, if they are in the usual situations in the body, the mites would probably produce no diseased conditions. The attention of the poultry raisers is to be directed entirely to preventive measures. Various methods of disinfection of poultry houses which have been recommended as serviceable in case of infestation by other mites and chicken insects, would be equally effective if used against Cytodites. The possibility of this mite causing occasional slight losses of poultry merely gives an additional reason for keeping poultry houses and yards clean and for making occasional thorough applications of disinfectant methods of known value.

The literature relating to Cytodites. so far as known to the writer, is brought together in the following brief summary:

LITERATURE ON CYTODITES NUDUS.

Berlese, A. Acar. Myr. Scor. 1879, fasc. 84, No. 7.

Canestrini, G. Pros. Acar., 5 (1893), p. 566.

Edgar, W. A. A new (?) parasitic disease. Veterinarian, 59 (1886), pp. 409,410, figs. 3.

Gerlach. Einige neue Parasiten bei den Hausthieren. Mag. f. die gesammte Thierheilk., 25 (1859), No. 1, pp. 232-255, pl. l.

Holzendorff. Arch. Wiss. u. Prakt. Thierh., 1885, p. 304.

Megnin, P. Les acariens parasites du tissu cellulaire et des reservoires æriens chez les oiseaux. Jour. de Ant. and Physiol., 15 (1879), pp. 123-153, pls. 2.

Megnin, P. Memoir presente a la reunion des Societes Savantes a la Sorbonne, 1876.

Megnin, P. Monographie de la tribu des Sarcoptides psoriques etc. Rev. et Mag. de Zool., 1887.

Megnin, P. Les Parasites et les maladies parasitaires chez l'homme et les animaux domestiques, etc. Paris, 1880.

Neumann, L. G. Treatise on the parasites and parasitic diseases of the domesticated animals. Trans. by G. Fleming. London, 1892.

Osborn, H, Insects affecting domestic animals. U. S. Dept. Agr., Division of Entomology Bul. 5, n. s.

Paulicki. Milben in den Luftsacken einer Goldfasanhenne. Wien. Med. Wchnschr., 19 (1869), p. 993.

Perroncito. Parassiti p. 429.

Piana, G. P. Ricerche sopra una epizoozia dei gallinacei osservata nella Provincia di Bologna. Gaz, Med. Vet. Naples, 6 (1876), Nos. 3 and 4, pp. 257-282, pls. 2.

Raillet, A. Traite de zoologie medicale. Paris, 1895.

Riley, C. V. Amer. Nat., 17 (1883), pp. 422,423.

Rivolta, S. and Delparato, P. L'Ornitojatria o la medicina degli uccelli domestici e semidomestici. Pisa, 1879, p. 508, pls. 4.

Taylor, T. Internal parasites in the common fowl. Proc. Amer. Soc. Micros., 1883, pp. 131-133, figs. 2.

Intestinal parasites in domestic fowls. Sci. Amer., 49 (1883), p. 212.

Salmon, D. E. Diseases of poultry. Washington, 1899.

Taylor T. Sci. Amer. Sup. 18 (1884(p. 7414.

Theobald, F: V. Parasitic diseases of poultry, London, 1896.

Vizioli, F. Osservazioni microscopische sopra alcuni noduli sottocutanei dei polli e descrizione di un unovo genere di acaridei parasita degli uccelli. Gior. Anat. Fisiol. Pato Animali 1 (1869), pp. 257-271, pl. 1.

Wilcox, E. V. The internal chicken mite (*Cytodites nudus*). Jour. Comp. Med. and Vet. Arch., 19 (1898), No. 8, pp. 523-526.

Williams, W. L. Amer. Vet. Rev. April, 1898.

Zundel, A. La Phthiriase interne. Jour. Med. Vet. Lyon, 20 (1864), pp. 565-573.

Zurn. Die Krankheiten des Hausgeflugels. Weimar, 1882.

Zschokke, E. Schweitzer-Arch. Thierh., 26 (1884), No. 1, pp. 20-25, figs. 3.

Lupines as Plants Poisonous to Stock.

The lupines constitute a genus of plants which belongs to the family of legumes and has a wide distribution over the surface of the earth. In the United States these plants are most numerous and well developed in the western portion of the country, especially in the Rocky Mountain and Pacific coast regions. The genus includes a considerable number of species in the United States, but the species which is most common and of greatest economic importance in Montana is *Lupinus leucophyllus*. This species may be briefly described as follows; The plant grows to a height varying from 6 inches to 3 or 4 feet and develops a corresponding variation in horizontal spread, depending upon the soil and other conditions of its surroundings. The stems of the lower leaves are much elongated, so as to bring the leaves themselves nearly up to a level with the other leaves which are attached higher up upon the stem. Each leaf is compound in a digitate manner, being made up of from seven to ten oblong wedge-shaped leaflets all arising from the same point. The plant is hairy throughout, the hairs upon the stem and leaves being so close together and of such length that the plants are thereby given a grayish color which obscures the green to a greater or less extent. The hairiness of the plants varies to a greater or less extent, depending upon the weather and soil conditions. In damp situations the plants appear a darker green and are not so hairy, while in dry situations the green of the leaves is more obscured by the excessive development of plant hairs. The plants branch diffusely, but the largest and most important raceme of flowers are of a bluish color and from three to five lines in length. Occasionally individuals are seen with white or pink flowers, but the prevailing color is a shade of blue. The flowers are arranged in dense terminal clusters or racemes, and during the flowering season the lupine constitutes in many parts of the State a conspicuous and beautiful feature of the landscape.

The common species of lupine in Montana ordinarily grows in localities where the soil is slightly moistened by seepage. Lupines reach a luxuriant growth and development along irrigation ditches and it is plain, therefore, that a considerable quantity of water is not unfavorable to their growth. In many areas which are in their natural condition and have been thus far undisturbed by man, the lupines completely cover the ground and thus furnish a forage crop of considerable importance.

Before discussing in any detail the value of lupine as a forage crop, or as green manure, or the possible danger arising from their use as fodder on account of their poisonous properties, it seems advisable to call attention to certain common mistakes concerning the identification of lupines. One frequently notices illustrations of species of Astragalus and Oxytropis which are called lupines or loco weeds indiscriminately, and agricultural newspapers have frequently confused the loco weeds with lupines, or have referred to them as being the same species. This confusion of different species of native legumes is unfortunate, especially since it renders difficult the acquisition of any accurate data concerning these plants by stockmen. If the stock owner does not take the trouble to distinguish between plants of such different appearance as the lupine and the ordinary loco weed (*Astragalus mollissmus*), it is impossible to obtain from him reliable information concerning the use of these plants for forage purposes or their poisonous effects upon domestic animals.

Lupines have not been cultivated as forage crops in the United States to any great extent. The California station has been experimenting for a number of years with various European and native species of lupines for the purpose of determining their value as green manures and also their forage value. Aside from these experiments, practically nothing of importance has been done in this country. In Europe a considerable number of species have been cultivated ever since the beginning of the Christian era. The plants have been cultivated as forage crops for domestic animals, and the seeds have been used as food for man and domestic animals. The old Latin and Greek writers refer to the medicinal and poisonous principles contained in lupine seeds and also to the use of the plants as fodder. More or less extended references to lupines are made in the writings of Cato, Columella, Dioscorides, Palladius, Pliny, Varro, and Theophrastus. The Latin authors referred to the plant by its present botanical name, Lupinus, but the Greek name for the plant was Thermos. The seeds have been used for medicinal purposes, and even in Pliny's time we find that lupine was recommended as beneficial in thirty-five medicinal ways. In modern times the seeds have been used for diuretic and anthelmintic purposes.

The literature relating to lupines as forage and food plants and as plants poisonous to stock is very extensive. The writer has consulted a list of not less than 300 titles which include all possible uses and relationships of lupines. The greater part of the recent more valuable work on lupines has been done by the Germans and Italians. A considerable part of this work consists in extensive analyses of the seeds of lupines at different stages and of the other parts of lupine plants.

Several poisonous alkaloids have been extracted from lupines, of which may be mentioned the three most important, lupanin, lupinin, and lupinidin. There is a large amount of technical chemical literature upon the methods of extraction of these alkaloids and upon the physical and chemical characters of the alkaloids.

It has been recognized since the time of Pliny that lupine seeds contain poisonous principles, and methods were devised even in his time for the extraction of these poisonous principles or the disembittering of the lupine seeds as it is called at present. These methods were at first crude, consisting in the mere boiling of the seeds in pure water or water and ashes and the pouring off of this water. In recent times numerous more elaborate methods have been devised, many of which have been patented, for the disembittering of lupine seeds.

The poisonous effects of lupines upon stock, especially upon sheep, have been studied extensively in Germany and Italy, and the symptoms have become so well known and are so constant and uniform that the disease caused by the lupine poisoning has been called lupinosis. Where sheep are fed upon small quantities of lupine for a considerable time, they finally show symptoms of jaundice, but these symptoms are notapparent in cases which develop more rapidly from the eating of large quantities of lupines at a few feedings. In Germany the loss of sheep from lupine poisoning is a serious matter, whole herds being affected simultaneously. The symptoms, as described by Dr. Dammann, are congestion of the head and violent excitement which results in butting the head against various objects until general spasms result. Vertigo and an increase in the rapidity of the respiration and pulse are noticed in acute cases.

The writer has had occasion to observe a number of cases in Montana which were in all probability due to lupine poisoning. These cases were mostly confined to sheep, but a few horses were among the observed cases of lupine poisoning. It may be well to relate a few facts by way of history of these cases in order that the stock grower may have the evidence before him.

A stock grower in Madison Valley had a band of 200 bucks which he had been feeding upon cultivated varieties of hay until this hay was exhausted. The bucks were then fed upon lupine hay during the afternoon, and in the evening of the same day the sheep manifested symptoms which were at first not well understood by the owner. The sheep were at the time enclosed in a strong corral and were found in the evening to be in a state of great excitement, butting one another and the posts of the corral. About one-half of these bucks died during the night. The owner, suspecting the lupine hay of causing the loss, bought some cultivated variety and no further trouble was experienced among this band of sheep.

In the latter part of July, a sheep owner while driving a band of sheep from one range to another, allowed them to stop in a field of lupine. The sheep were hungry and ate voraciously of the lupine, which at the time had nearly matured its seeds. The sheep showed poisonous effects of the lupine seeds within a few hours and nearly one-half of the band died within a period of 24 hours.

During the autumn snowstorms of 1898, extensive losses of sheep occurred which were in most instances referable to poisoning by lupine. In the Madison Valley about 150 sheep died from this cause. In Cascade County the losses amounted to about 300 while in the Smith River Valley the deaths from lupine poisoning amounted to nearly 2,000; 1,150 died of one band of 2,500. The cases of sheep losses from lupine poisoning which happened in Madison Valley were reported to the writer by the owners of sheep who presented specimens of the lupine for identification. In the case of the losses which occurred in Cascade County, the sheep being fed wild hay and this hay being suspected of causing the death of the sheep, a considerable quantity of it was forwarded to the station for examination. The hay was composed largely of lupine with an occasional plant of wild geranium and sage. The station received the stomach contents of a number of sheep which died in the Smith River Valley, and it was found that they contained large quantities of lupine pods and a considerable number of the seeds. Lupine grows abundantly on the ranges where the sheep were at the time of the poisoning and there seemed to be little reason to doubt the agency of lupine in the case.

During the same winter a few young horses near Great Falls were taken in from the range and fed upon wild hay. They soon manifested serious symptoms of sickness and two of them died. The stomach contents of one were forwarded to the station for examination, with the result that lupine was found in the stomach in large quantities. During the same autumn a horse which had been imported from the East into Bozeman was fed with lupine hay and developed symptoms of serious poisoning within a few hours after eating the hay. The owner was advised not to feed any more of this hay, and the horse finally recovered from the attack. The symptoms in this last mentioned case were rapid pulse, difficult respiration, and involuntary muscular movements.

It is well known that lupine is used to a considerable extent as hay in the State and that under some circumstances it seems not to be harmful. In many parts of the State, stock raisers cut tons of practically pure lupine for hay. It grows in many situations as already indicated, to a considerable height and covers the ground completely. A heavy crop of this plant may, therefore, be secured for hay. Probably not less than 5,000 tons of lupine hay are made annually within the State. It is eaten readily by domestic animals, even young calves devouring completely the hard woody stems of the larger plants along with the foliage and flower clusters. Such analyses as have been made of the plant would indicate that its nutritive properties are of a high order. It would, therefore, seem to be a valuable forage plant provided that the danger from poisoning could be avoided. The fact that lupine is at times evidently poisonous and at other times harmless, renders the problem more difficult. As long as stock raisers can obtain an abundance of this plant for hay upon their ranches with a very slight expenditure of energy, it would seem of doubtful propriety to recommend the entire abandonment of this practice.

In all cases of poisoning from lupine which have come to the writer's attention, the plant has been eaten in a mature condition. When the lupine is cut before the ripening of the seeds, it appears not to produce any poisonous effects upon stock. The plants are less woody if cut shortly before becoming mature, and it seems therefore advisable from every consideration to cut the lupine at about the time of full bloom, and by all means before the ripening of the seeds.

In the cases of poisoning which took place after the snowstorms, the circumstances were as follows: The short grasses and other edible plants of the range were covered by the snow and the only plants which remained above the snow were lupines and sage brush. At this time of the year the lupines contain a few seeds, although perhaps the majority of the seeds have already fallen to the ground. An examination of lupine plants during mid-winter disclosed the fact that a considerable number of the seeds are retained in the pods at that time, although the valves of the pods have split apart and twisted to a considerable extent.

The only experimental work in feeding lupines in this country which has come to the writer's attention, is that of Dr. Nelson of the Washington station. This observer fed 8¼ pounds of lupine to one sheep within three days without any noticeable effects. The experiment lasted from May 30 to June 1, inclusive. Dr. Nelson does not state what species of lupine he used in his experiment. Regarding this experiment it is perhaps not necessary to state that no poisonous effects would be expected from the lupine when fed so early in the season. The seeds at that time of the year could not possibly be ripe and it is well known from numerous observations in Europe and this country that the other portions of the lupine plant, aside from the seeds, contain only a small percentage of poisonous principles. This is not a condition which is peculiar to the lupine, for it is well known to pharmacists that all drugs must be collected at certain times of the year or in certain stages of growth in order to obtain the active principles which are desired in those plants. The poisonous and medicinal properties of plants are not usually present in equal strength in different parts of the plant and at some stages of growth are not present at all, or in the merest traces. Extensive series of analyses which were made in Germany of lupine plants during the various stages of growth from germination to the maturity of the seeds, demonstrated that lupine furnishes no exception to these general conditions, and that very striking and important changes in the chemical constitution of the plant took place during its successive periods of growth.

No chemical analyses, so far as is known to the writer, have been made of American species of lupine. The alkaloids which they contain are, therefore, not known with certainty.

The condition of the lupine problem may, therefore, be stated as follows: In European countries the native species of lupine have been found to be poisonous to man and domestic animals. The poisonous principles have been extracted and described as to their physical, chemical, and medicinal properties. Experiments have been conducted in feeding these alkaloids to animals and results have been thus produced which are identical with poisoning under natural conditions. Various methods have been devised for the extraction of the poisonous principles upon a large scale and in an economic way. In this country it is known that sheep, cattle, and horses feed upon lupines in the growing condition and as hay. It has also been observed that serious cases of poisoning and death result, especially among sheep, from eating lupines when in a mature condition. It seems, therefore, highly probable that detailed chemical analyses of American species of lupine will demonstrate the presence of poisonous alkaloids similar to those already extracted from European species.

The literature of the subject is almost entirely of European origin and is so extensive that only a few of the more important European articles are mentioned.

Callsen, J. Ueber die Alkaloide der Samen von Lupinus angustifolius und von L. perennis var. polyphyllus. Arch. Pharm. 237 (1899), No. 8, pp. 566-595.

Dammann. Ueber Schafheerden-Erkrankungen durch Lupinen. Deut. Ztschr. Thiermed., 3 (1877), pp. 353-367.

Davis, L. S. Ueber die Alcaloide der Samen von Lupinus albus und L. angustifolius. Inaug. Diss., Marburg, 1896.

Davy, J. B Lupines for green manuring. California Sta. Bul. 124.

Kette, W. Die Lupine als Feldfrucht. Berlin, 1891, pp. 124.

Nelson, S, B. Feeding wild plants to sheep. U. S. Dept. Agr., Bureau of Animal Industry 15th Annual Rpt.

Steiner, L. Ueber Entbitterung und Entgiftung der Lupinenkorner. Inaug. Diss. Halle, 1894, pp. 32.

Wilcox, E. V. Sheep poisoning. Rocky Mountain Husbandman, October 27, 1898.

About 80 articles dealing exclusively with the alkaloids of lupine seeds have been published by the following authors: G. Baumert, G. Gampani, L. S. Davis, H. Ritthausen, E. Schulze, A. Soldaini, and E. Steiger.

In bibliographical references accompanying articles on lupines, one notices occasional titles on lupulin and lupinella. Lupulin is an alkaloid from the hop and lupinella is the Italian name for sanfoin.

Atwater. W. O. and Woods, C. D. Atmospheric nitrogen as plant food. Connecticut Storrs Sta. Bul. 5, pp 18.

Blount, A. E. Experiments with field crops at New Mexico Station. New Mexico Sta. Bul. 6, pp. 19.

Breninger, G. F. Report of the Divide Substation. Colorado Sta. Rpt. 1892, pp. 61-69.

Cassidy, J. and O'Brine, D. Some Colorado grasses and their chemical analysis. Colorado Sta. Bul. 12, pp. 151.

Dyer, H. P. Some California weed seeds. California Sta. Rpt. 1890, pp. 252-266.

Goessmann, C. A. Field experiments. Massachusetts State Sta. Rpt. 1889, pp. 148-194.

Goessmann, C. A. Experiments with field and garden crops. Massachusetts State Sta. Rpt. 1890, pp. 169-186.

Goessman, C. A. Field experiments. Massachusetts State Sta. Rpt. 1891, pp. 180-217.

Goessmann, C. A. Field experiments. Massachusetts State Sta. Rpt. 1892, pp. 170-212.

Goessmann, C. A. On fodder articles and fodder supplies. Massachusetts State Sta. Bul. 45, pp. 15.

Goessman, C. A. Experiments with forage plants. Massachusetts State Sta. Rpt. 1893, pp. 212-219, pls. 4.

Goessman, C. A. Forage crops. Massachusetts State Sta. Rpt. 1894, pp. 231-256, 262, 263.

Halsted, B. D. Report on fungus diseases of plants. New Jersey Stas. Rpt. 1891, pp. 233-340, figs 24.

Hilgard, E. W. Weeds of California. California Sta. Rpt. 1890, pp. 238-252.

Johnson, S. Forage plants. Michigan Sta. Bul. 47, pp. 42-45.

Lee, J. G. Experiments with forage plants, etc. Louisiana Stas. Bul. 8, 2 ser., pp. 48.

McCarthy, G. and Emery, F. E. Some leguminous plants. North Carolina Sta. Bul. 98, pp. 135-150, 157-170.

McDowell, R. H. Report of agricultural section. Colorado Sta. Rpt. 1890, pp. 14-24.

Mills, A. A. Sorghum and other forage crops. Utah Sta. Rpt. 1893, pp. 233, 234.

Osborne, T. B. and Campbell, G. F. The proteids of lupin seeds. Connecticut State Sta. Rpt. 1896, pp. 342-368.

Osborne, T. B. and Campbell, G. F. The proteids of lupin seeds. Jour. Amer. Chem. Soc., 19 (1897), No. 6, pp. 454-500; reprint from Connecticut State Sta. Rpt. 1896, pp. 342-368.

Rane, F. W. Lupinus albus. New Hampshire Sta. Bul. 57, pp. 143, 144.

Sanborn, J. W. Varieties of grasses, forage plants, and corn. Utah Sta. Rpt. 1892, pp. 67-76, 190-208.

Smith, J. G. Grasses, clovers, and other forage plants. Nebraska Sta. Bul. 6, pp. 32-46.

Stubbs, W. C. Field experiments with forage plants, barley, oats, and wheat. Louisiana Stas. Bul 19, 2. ser., pp. 586-562.

Weed, H. E. Notes from the Mississippi Station. Insect Life, 5 (1892), No. 2, pp. 110, 111.

Woods, C. D. Fertilizing ingredients in crop and in roots of legumes. Connecticut Storrs Sta. Rpt. 1890, pp. 29-36.

Woods, C. D. and Phelps, C. S. Grasses and legumes. Connecticut Storrs Sta. Bul. 6, pp. 16.

Cattle Poisoning by the Tall Larkspur.

Two species of larkspur are common and conspicuous plants in Montana. The smaller species, *Delphinum menziesii,* has already been discussed in Bulletin 15 of this station. The other common species, which is for convenience called the tall larkspur, is also mentioned in Bulletin 15 under the name of *D. glaucum.* This specific name, however, is perhaps better retained as a mere variety of *D. scopulorum*, and the common tall larkspur of Montana is, therefore, referred to in the present discussion under the name *D. scopulorum.* In many parts of the State this plant is commonly known as aconite, the smaller species of larkspur being called simply larkspur. Larkspur and aconite, however, belong to two distinct genera and the native species of aconite in the State has a rather limited distribution, being found for the most part at high altitudes in Gallatin County in the vicinity of the Yellowstone Park.

The tall larkspur grows to a height of from 2 to 6 feet, depending upon the moisture and richness of the soil. The leaves are nearly circular in general outline. They are parted into three to five divisions and these divisions are again cleft two or three times, the ultimate subdivisions of the leaves being cut-toothed. The plant, as a whole, varies from a smooth to a rather hairy condition, and the flowers are nearly always silky-hairy on the outside. The flowers are of the same shape as those of other species of larkspur and are borne in a long terminal raceme. The color of the flower varies from a dark blue at high altitudes to a pale blue in lower altitudes, or even to a nearly pure white. The pods of the tall larkspur are hairy and at maturity are borne erect on stout pedicils. This species is distributed very generally in the State, having been observed in Flathead, Teton, Missoula, Ravalli, Deer Lodge, Lewis and Clarke, Jefferson, Madison, Gallatin, Sweet Grass, Park, Yellowstone, Carbon, and Meagher counties. It occurs at all altitudes up to 9,000 feet or more.

The soil conditions under which the tall larkspur seems to flourish best are similar to those which are favorable for the growth of the small species of larkspur. The two species, however, are seldom found growing together. The small species is often seen in cultivated ground which has been allowed to run fallow, while the tall larkspur is rarely seen in such situations. The latter species is most abundant in ranges with a moderate amount of moisture. It is usually found in such situations in company with the common wild geranium and cinquefoil, but it does not occur in dry situations either of high or low altitudes. The species seems to prefer the moist ground which surrounds natural springs upon hillsides or at the sides of the large grazing valleys. In these situations it grows to a great height, and is usually the most conspicuous of the plants which are found in such areas.

The tall larkspur has a bitter acrid taste which is exceedingly disagreeable to the human palate, and if cattle were not actually known to eat the plant, it would seem improbable that they ever did so. It is, however, as a matter of fact, eaten to a large extent, the leaves and flowering stems being greedily devoured and partially pulled up by the roots during wet seasons.

In the spring of 1898, the writer and Dr. Traphagen investigated an outbreak of cattle poisoning which occurred in the Gallatin Basin and during which about 40 cattle died. It was found upon making a study of the range that the tall larkspur grew abundantly in the places where the cattle had been feeding. A late spring snowstorm had occurred which covered up the grass and shorter vegetation, and the larkspur, which at the time stood about 3 feet in height, had been eaten off nearly down to the ground. The cattle without exception were found dead in the patches of larkspur, and the symptoms which they manifested, so far as could be as ertained from the man in charge of them, were similar to those of poisoning by the smaller species of larkspur. The owner of the cattle stated that he had frequently lost cattle under similar circumstances and with similar symptoms and that the poisoning usually occurred after late spring snowstorms when the cattle were forced to eat the larkspur which was the only green thing above the snow.

During subsequent extensive trips over different parts of the State, the same condition of affairs was found to be true. Wherever cattle were allowed to range in native pastures upon which the tall larkspur grew, a few cattle died nearly every spring from eating this plant. The coincidence of dead cattle and tall larkspur is at such times so common that it was noted and frequently remarked on trips over the State that the odor of dead animal in the majority of cases indicates the presence of tall larkspur. Such was found to be the case on repeated examination in various parts of the State.

It is not believed that any great number of cattle are poisoned by this plant during any single spring, but the sum total of loss from the tall larkspur is a rather serious matter. It would be a comparatively easy matter for stock owners to familiarize themselves accurately with the exact localities upon their ranges where this species is found and to keep the cattle away from such places during the dangerous season.

Dr. Traphagen called the writer's attention to the fact that in some meadows the tall larkspur grows rather abundantly with the ordinary grass of the meadow, and it is therefore cut for hay along with the grass. In the cases of this sort which were investigated, it was found that the larkspur constituted a small part of the hay, and it is probable that on account of its coarseness it would be avoided by cattle in the dry condition.

No ultimate chemical analyses have been made of this plant, but it is evident from the large number of cases which have come to the writer's attention that the plant is equally poisonous with the small species of larkspur. Usually when cattle are poisoned with this plant, they are not seen in time to be saved by the application of artificial remedies. Almost the only general suggestion that can be made in connection with the avoidance of loss from this plant is to study the ranges, locate the areas of the larkspur and keep the cattle away from such places, especially after spring snowstorms.

Poisoning of Stock by the Water Hemlock.

The water hemlock belongs to the parsnip family and has the general appearance of the wild parsnip, by which name it is often improperly known. The plant is perennial and grows in wet or marshy localities. The flowers are white and are borne in a terminal flat-top umbel. The leaves are pinnately compound and separate leaflets are sharply serrate. It is known in the State by the common names of water hemlock, water parsnip, and wild parsnip. Its scientific name is *Cicuta maculata*.

Cases of poisoning of man and domestic animals by this plant have been reported from a number of States, and its poisonous character is well known and undoubted. In the spring of 1898 two persons mistook the plant for parsnip and ate portions of the root. Both men died from the effects. In the Smith River valley the plant is occasionally eaten by sheep, with fatal results. A few cases cf poisoning of dairy cows by water hemlock came to the writer's attention during the summer of 1898. The symptoms were those of severe pain accompanied by cerebral excitement and spasms. In one case the cow lived only 15 minutes after the first symptoms of poisoning. In the other cases the paunch was opened from the side and contents removed, with final recovery as the outcome.

Very little can be done by the way of direct remedy in case of serious poisoning by this plant, and the attention of stock owners is, therefore, to be directed to the eradication of the plant or the prevention of stock from eating it. Water hemlock grows only along small streams or in marshes. Its distribution is, therefore, well marked and the stock owner may know where to expect its presence. It would seem possible and very practicable to fence in areas in which this plant is found and thus prevent cattle from eating it during the season when it is green and tempting as a forage plant. Later in the season cattle might be safely allowed to pasture in these marshy areas. The ground would then be drier and the danger from water hemlock would be past.

Ergotism in Horses.

Everybody is familiar with the small black spurs which are so often seen in the heads of rye grass and many other grasses. This spur is the fruiting mass of a fungus which is known to botanists as *Claviceps purpurea*, and is commonly known as ergot. Ergot has been found on a considerable variety of cereals and grasses. In Montana it has been observed upon blue joint, meadow grass, several species of rye grass, canary grass, and *Koeleria cristata*.

Ergot is much more prevalent during some years than others, and during years of its greatest prevalence, it assumes an economic importance not so much from its destructiveness to grains as from the danger to domestic animals from eating it upon grasses.

The medicinal effects of ergot are well known. It is frequently given in veterinary practice in medicinal doses, but in excessive quantities it produces a number of serious effects, such as abortion and gangrene of the legs. When taken in repeated small doses, it has another effect to which reference is less often made. This may be described as a progressive paralysis beginning with the tongue and swallowing apparatus and finally involving the whole body. This effect is referred to in general works on toxicology, but the ordinary meaning of ergotism as a disease of cattle is gangrene of the legs with subsequent sloughing of the skin and underlying tissue of the affected parts. A number of cases were observed in horses which were to all appearances due to feeding upon wild hay which was infested with ergot. The symptoms which were manifested were as follows: It was first noticed that the animal could swallow only with difficulty, and this difficulty became greater and greater until it was soon impossible for the animal to swallow either water or hay. There was manifested a general depression of the vital functions, the respiration and pulse being slow and weak and the sense organs being less responsive than usual. The course of the disease was usually a rapid one and ended in the majority of cases in death within from 6 to 12 hours, the symptcms during the latter stages of the disease being those of a general and aggressive paralysis of the whole muscular system and a muscular inco-ordination. The animal would lie dcwn and get up rather frequently but did not show any excitement nor pain, and death resulted in a very gradual manner. Upon making a post mortem examination it was found that the stomach contained considerable quantities of blue joint which was badly infested with ergot, numerous spurs of ergot being still undissolved. It was found upon investigation of the hay which was fed to these horses that ergot was unusually abundant.

The only remedies which were tried in combating the disease were such as were indicated by the symptoms and were confined to attempts to combat the symptoms as they appeared. The throat was blistered when paralysis of the pharynx was manifested and generally stimulants were applied, such as whiskey by way of mouth and strychnine hypodermically. In two cases recovery took place after about two days, but in all other cases death resulted within twelve hours.

It is the custom in many localities to cut wild blue joint and rye grass for hay to be fed to stock during the winter. These two grasses are apt to be infested with ergot and during the past two years have been infested to quite an unusual degree. It would seem advisable that these grasses be cut before they are ripe and before the ergot spurs are formed, in order to prevent the bad effects of overdoses of ergot. Wild rye grass is usually avoided by stock and probably not eaten when other food can be secured in proper quantities. When, however, this species is offered as hay it is readily eaten by horses, and if badly infested with ergot, is almost certain to produce more or less serious symptoms either of the form described above or of the better known form of gangrene of the legs. Two cases of this latter form were observed and in both of these cases it was determined by inquiry that the horses had eaten large quantities of wild rye grass which was badly infested with ergot. It was impossible to discover what should determine the development of one set of symptoms in one case and of another set in another case. There seems, however, no reason to doubt that the symptoms, which consisted in paralysis of the throat and a later general paralysis of the body muscles, were due to the eating of ergot upon wild grasses, Loss from this cause may be easily prevented by avoiding the use of such of the above mentioned grasses as hay except when they are free from ergot.

The Poisoning of Cattle by Smutty Oat Hay.

Rather extensive studies have been made of the effects of corn smut and various moulds upon stock when eaten in considerable quantity. Certain investigations have shown that corn smut produces symptoms in cattle which have been called the cornstalk disease. Little, however, has been done by way of study of the ordinary loose smut of oats in relation to its poisonous effects upon cattle.

During the winter of 1898 a dairyman near Bozeman suffered the loss of twelve dairy cows from feeding smutty oat hay. The cows had been receiving clover and alfalfa previous to being fed with the oat hay. During the previous season the owner of the cows discovered that one of his fields of oats was so badly smutted that he considered that the crop would be worthless for grain. He therefore cut the oats before they became mature and stored the material for hay. The loose smut of oats ordinarily blows away so as to leave but a small quantity of the spores attached to the straw, but since the crop of oats in question was cut before it became ripe, nearly all the smut remained with the oat hay and was thus eaten by the cows. Out of thirty cows which received one feeding of the smutted oat hay twelve died within eighteen hours after feeding, with symptoms of gastric disturbances and excitement somewhat similar to cerebro-spinal meningitis. The owner of the cows at once stopped feeding the oat hay and began again upon the clover and alfalfa with the result that no further loss took place. These cases of poisoning suggest rather forcibly the desirability of treating seed oats so as to prevent the development of smut.

List of Plants of Known or Suspected Poisonous Properties Which Grow Within the State.

As is generally well known, extensive losses of stock occur during certain seasons of the the year in almost all parts of the United States as a result of eating poisonous plants. Undoubtedly the number of plants which actually poison stock in different parts of the country is a arge one, but the list of plants which are suspected of being poisonous y stock growers in different localities is much larger. V. K. Chesnut has brought together a list of plants which are known to be poisonous, or suspected or reported as being poisonous in an article entitled "Preliminary Catalogue of Plauts Poisonous to Stock" in the Fifteenth Annual Report of the Bureau of Animal Industry. The list of plants reported in this article is divided into three categories: Plants known to be poisonous, plants which are probably poisonous, and plants which are suspected of being poisonous. These three categories of plants include a rather large number of species, many of which are found in Montana.

Among the species which are known to the writer to be poisonous or which have been suspected by stock owners in the State of being poisonous, may be mentioned the following:

Loco weed (*Astragalus mollissimus*).
Loco weed (*Astragallus lambertii*).
Rattleweed (*Crotalaria sagittalis*).
Lupine (*Lupinus leucophyllus*).
False hellebore (*Veratrum californicum*).
Alkali grass (*Zygadenus elegans*).
Death camass (*Z. venenosus*).
Leucocrinum montanum.
Purple larkspur (*Delphinium menziesii*).
Tall larkspur (*D. scopulorum*).
Aconite (*Aconitum columbianum*).
Water hemlock (*Cicuta maculata*).
Yellow flax (*Linum rigidum*).
Nightshade (*Solanum triflorum* .

Of the species mentioned in this list, the purple and tall larkspur, aconite, lupine, death camass, nightshade, and water hemlock are certainly poisonous and are known to have caused death to animals in the State. The two loco weeds which are mentioned are those which are most commonly believed by stockmen of the State to be the cause of the disease known as loco. The real cause and nature of this disease is, however, undetermined and no definite statements can be made concerning the poisonous characters of these two plants.

Yellow flax has been reported to the writer as causing the death of a few sheep. The symptoms as described, however, were not well defined and the circumstances surrounding the case were such as to preclude any definite conclusion concerning the cause of the sheep dying

The nightshade was reported as having caused the death of pigs. This supposition could not be verified completely, but it seemed a plausible conclusion to draw from the circumstances of the case. The plant is known to contain poisonous principles.

The false hellebore has a very local and irregular distribution in the State, occurring in great abundance, however, in the few localities where it is found. In two localities where it occurred in the greatest abundance, loss of cattle was reported as due to poisoning by this plant.

Accounts have been given elsewhere of the water hemlock, lupine and larkspur. Leucocrinum grows very abundantly upon a number of the larger sheep ranges and was repeatedly sent to the writer with accounts of sheep poisoning and statements of the belief that this plant was the cause of the poisoning. It seems, however, highly improbable that this plant is poisonous at all. The writer investigated a number of supposed cases of poisoning from this plant and found that in each instance the sheep had been eating other plants which are known to be poisonous. Furthermore, it was not possible to determine that Leucocrinum was eaten at all by the sheep. The leaves of the plant, as is well known, are not conspicuous and, therefore, do not furnish tempting forage for the sheep. It has been suggested that the fruit of this plant may be poisonous, but since the fruit is formed underground and since the plants grow in such dry localities that it is impossible to pull up the fruit or to get it without digging, it seems highly improbable that that the sheep ever eat any part of the plant except the leaves.

Much confusion and uncertainty are prevalent among stock owners regarding the names of various plants which have been suspected of being poisonous, and this renders it necessary in almost every case of reported poisoning to make an investigation of the locality in question. In some localities the tall larkspur is commonly known as aconite, the purple larkspur has been confused with lupines, and the lupines in turn have frequently been considered the same as loco weeds. It is advisable that plants which are suspected of poisoning stock should be sent at once to the Station for identification in order that more accurate knowledge may be obtained of the case. It is not improbable that some plants at present supposed to be poisonous will prove on a more thorough investigation to be non-poisonous, and, on the other hand, it is likely that a study of the matter will show that some plants which are at present not suspected, are really poisonous.

Some Native Forage Plants of the State.

While traveling over the State for different purposes, numerous observations were made upon the plants which furnish the chief forage upon the ordinary range and in uncultivated hay. A few notes are here brought together upon a number of plants which are of greater or less importance as forage. These plants are of value either for range forage or for hay, and in some instances the same species is often used for both purposes.

A number of species of sage-brush, particularly *Artemisia cana* and *A. tridentata*, are eaten by sheep during the winter. *A. cana* constitutes an important part of many samples of uncultivated hay which were examined in different parts of the State, *A. tridentata*, which is the botanical name for the ordinary shrubby sage-brush, naturally cannot be cut for hay, but the leaves and smaller twigs are frequently eaten by sheep to a considerable extent. Both of these species of sage-brush have a wide range of distribution and are, as is well known, very abundant in nearly every part of the State.

Licorice, *Glycerrhiza lepidota*, is a widely distributed and common species of plant in Montana. Along the Missouri River Canyon it is exceedingly abundant and is cut for hay on a large scale. Especially near Cascade and Kalispell the plant is cut for hay to a limited extent, and it was observed that licorice was greedily eaten by cattle and horses upon the range. Licorice grows to a considerable height, and the lower part of the stem becomes very woody. As is well known, the spiny burs of the mature fruit would also constitute one of the disadvantages of the plant as hay. The foliage and edible portions of the plant furnish good material for hay, however, if cut before the ripening of the burs.

Wild geranium is a plant which is found everywhere upon moderately moist hillsides of range country, and in such situations the writer has observed sheep, cattle, and horses feeding upon it. The plant does not become woody and is edible almost in its entirety. The wild geranium was frequently found in samples of uncultivated hay.

Five-finger, *Potentilla norvegica*, usually grows in company with the wild geranium, and its distribution is equally wide and general

The plant is readily eaten by cattle and sheep as hay, but upon the ranges it seems to be avoided when other more tempting forage plants are present.

Lupines constitute one of the most conspicuous natural forage plants of the State. As elsewhere indicated, lupines completely cover the ground in many places over large areas, and in such situations they are cut for hay to a considerable extent. Large quantities of lupine hay are cut in different parts of the State, and the writer has observed all kinds of domestic animals feeding upon lupine hay with apparent relish. Even the woody stems of the larger plants are eaten as well as the foliage and smaller branches. Lupines are also fed upon to a considerable extent by sheep and cattle on the range. A danger from the use of overripe lupine hay is alluded to elsewhere.

Sweet clover is not native to Montana, but both the white and yellow flowered species have been introduced and are rapidly spreading, In the Bitter Root Valley the yellow flowered species is quite abundant in certain localities, and the writer was informed that as hay it was greedily eaten by cattle. The white flowered species is found in the Gallatin valley, along the Missouri River Canyon, on the Belt Mountains. and in the Flathead Valley. This is merely the distribution as observed by the writer. It is probably found in many other localities.

Vetches, especially *Vicia americana*, are very abundant in native meadows over a large portion of the State. Many meadows were observed in the Milk River Valley, in which the material for hay was made up of about equal parts of blue joint and vetch. The vetch when growing in such situations, supports itself upon the stronger stems of blue joint and is thus enabled to reach a considerable height. The feeding value of the uncultivated vetches is well known. The wild species, so far as we know, has not been studied chemically. A shrubby species of meadow sweet (*Spiræa betulifolia*) grows very abundantly in the woodlands of the region about Flathead Lake. It was observed that cattle and horses seemed to prefer this to nearly all other native forage plants of this locality. The plant, as indicated, is woody, but the forage is abundant and the smaller branches are tender, the whole plant furnishing considerable forage.

So called loco weeds are eaten by stock on the range, and are occasionally to be found in uncultivated hay in various portions of the state. In the present unsettled condition of the loco problem it is not desirable to recommend the cutting of these plants for hay. The writer believes, however, that in the form of hay, especially if cut before maturity, many of these plants will be found harmless. It may be further observed that belonging as they do to the family of legumes and possessing an abundance of foliage they would constitute an important native forage plant provided it is shown in future investigations that they are not poisonous under the circumstances which were just indicated.

This short list of forage plants, it will be noticed, does not include any native grasses or sedges. It was the purpose of the writer merely to call attention to the rather extensive use of these plants on the range and as hay. Nearly all of the species mentioned, as indicated in the notes upon each one, are of wide distribution and of considerable abundance. The lupines, licorice, wild geranium and five-finger furnish a large quantity of hay which is fed during the winter to various domestic animals. The importance of these native plants for forage is probably greater than is usually supposed, for the additional reason that they do not require the care of man for their cultivation, and thus come to the stock owner as a gift of nature.

Cooley
6 3908, 679
M9eb

UNIV. OF MICH
JAN 18 [illegible]

BULLETIN NO. 23.

The Montana Agricultural Experiment Station

.....OF THE......

Montana College of Agriculture.

Injurious Fruit Insects; Insecticides; Insecticide Apparatus.

Bozeman, Mont., May 1900.

FRUIT GROWER PUBLISHING CO.,
MISSOULA, MONTANA

Montana Agricultural

EXPERIMENT STATION.

Executive Board.

LESTER S. WILLSON, President	Bozeman.
PETER KOCH, Secretary and Treasurer	Bozeman.
GEORGE KINKEL, Jr. Vice President	Manhattan
W. S. HARTMAN	Bozeman.
J. M. ROBINSON	Bozeman.

Experiment Station Staff.

S. M. EMERY	Director and Horticulturist.
F. W. TRAPHAGEN, Ph. D., F. C. S.	Chemist.
R. S. SHAW, B. S. A.	Agriculturist
J. W. BLANKINSHIP, Ph. D.	Botanist
SAMUEL FORTIER, Ma. E.	Irrigation Engineer.
R. A. COOLEY, B. S.	Entomologist.

Post Office, Express and freight Station, Bozeman.

All communications for the Experiment station should be addressed to the director.

MONTANA EXPERIMENT STATION,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

MONTANA EXPERIMENT STATION.

Bulletin No. 23. May, 1900

Injurious Fruit Insects.

The Codling Moth.

(*Carpocapsa pomonella Linn*)

DISTRIBUTION.

Europe is without doubt the original home of the codling moth. It occurs also in the United States, Canada, Australia, South Africa, Tasmania, New Zealand and Brazil. Generally speaking, we may say that it has made its home wherever the apple has been cultivated for any considerable length of time. It is very generally distributed throughout the apple growing regions of the United States and Canada, and has become best established in the oldest fruit growing regions.

OCCURRENCE IN MONTANA.

This insect was not known to exist in Montana until about three years ago, when a few specimens were found in Missoula. Late in the summer of 1899 Mr. I. D. O'Donnell rediscovered the pest in Missoula. It has not found its way, to any great extent at least, into the commercial orchards of Missoula county. At the annual meeting of the Montana State Horticultural Society, held at Plains in February, 1900, Mr. E. N. Brandegee reported having found it quite common in the home orchards of Helena and vicinity. Mr. H. C. B. Colvill has found the insect at Thompson Falls.

While it cannot be claimed that Montana is absolutely free from this dreaded pest, we can assert that it is not generally distributed through the state or established in a single orchard of any considerable size. In this respect Montana holds an almost unique position among the states and territories of the Union—a fact which should be dear to the heart of every one in the state interested in fruit growing. It cannot be hoped that the insect will be confined to its present limits, but, having already a State Board of Horticulture organized and at work, with authority to compel owners of infested orchards to spray them, and being at the outset practically free from the pest, Montana has a great advantage over other sections which are compelled to spray to obtain a profitable crop. It would be a great calamity to the orchard interests of the state should this pest become generally distributed. It is believed that our orchards, isolated as they are in many cases, can be kept reasonably free, and every effort to this end will be made. The law which provides for compulsory spraying will be rigorously enforced, and every effort will be made to retain for Montana apples their priceless reputation.

DESTRUCTIVENESS.

Beyond all doubt, the codling moth is of more importance to Montana friut growers than any other insect. The apple is the chief fruit in the state and the codling moth is its principal enemy. Conservative estimates place the annual loss from its destruction in different parts of the country where little or nothing is done to check its ravages, at from 25 to 75 per cent of the apple crop. Startling figures have been given by Prof. M. V. Slingerland, and others, showing the estimated loss to the crop from the insect in some of the principal apple growing states in the east. Montana now has apple orchards aggregating over 1,300,000 trees, according to statistics gathered by the State Board of Horticulture. It seems fair to estimate that by the time those trees come into full bearing capacity they will yield 10 boxes of fruit per tree. Apples have usually netted Montana producers about $1 per box. Figuring on the basis that these trees will produce only half the above amount per tree and that the fruit will only net 25 cents per box, we would have 1,300,000 trees producing 6,500,000 boxes of fruit worth $1,625,000. We may fairly estimate that should the codling moth be left to multiply and spread undisturbed, it would render unsalable fully 25 per cent of the crop. Montana would then pay an annual tribute of $406,250 to the codling moth. These estimates do not include injury to pears or to apples on trees planted in the future.

It is firmly believed that, considering the advantage we now have over the moth in being both forewarned and forearmed, fully 90 per cent of the loss which would occur did we make no effort to check the pest, may be saved to the fruit growers of Montana.

HABITS AND DESCRIPTIONS.

Like all moths and butterflies, the codling moth has four distinct stages of life, egg stage, larva or worm stage, pupa stage and adult or moth stage. The following descriptions of the different stages of the insect and account of its habits are taken largely from Prof. Slingerland's full and excellent account of the insect. (Bulletin 142, Cornell Experiment Station, 1898.)

The moth though so common in old orchards is rarely seen unless carefully sought for. It is a beautiful little insect with the fore wings colored with gray and brown cross lines. Near the hind angle is a large brown spot marked with streaks of bronze and gold. The hind wings are lighter, grayish brown, with darker outer border. The various stages of this insect are shown in Figure 1.

In northern United States, the moth makes its appearance in May and the early part of June. The time of its appearance, however, varies with seasons and with the place in which it passes the winter. The female is on hand to lay her eggs soon after the falling of the blossoms. The falling of the blossoms varies with the forwardness of the season but the same conditions affect also the development of the moth so that it appears each season at about the same time with reference to the blossoms. The moths are much more active after dark, and it is during the night that most of the eggs are laid. The eggs are very thin, whitish or yellowish, and about a twenty-fifth of an inch long. They are deposited anywhere on the apple, on the stem or even on neighboring leaves. Several eggs may be laid on one apple. One moth may lay only a few eggs or nearly a hundred, and several days are required to complete the process. Some of the eggs fail to hatch being infertile.

After about seven days the eggs hatch into minute worms about a sixteenth of an inch long, with shining black heads, thoracic, and anal shields. As the worm nears maturity, the parts which are at first black turn brown.

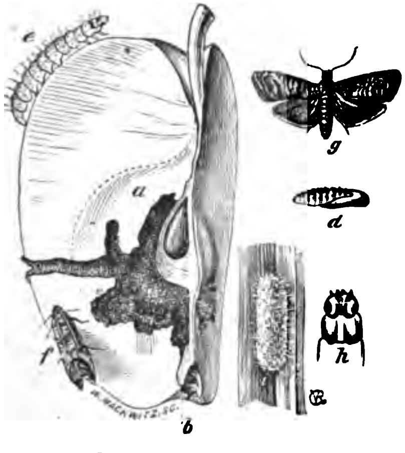


Figure 1 —Codling Moth: a, apple showing borings of the larva; b, place where the egg was laid; d, pupa; e, larva; f, g, moths at rest and with wings spread; h, head of larva; i, cocoon. (After Riley)

The newly hatched caterpillar wanders about on the surface of the apple in search of some irregularity in the surface where it can get hold with its minute mandibles and obtain its first meal. It often works its way between the calyx lobes which have been closed before it appeared. Thus the caterpillar may take its first meal from any part of the surface of the apple but more often from any part of the calyx lobes. This fact is of great importance since the presence of a poison on the fruit is fatal to a large per cent of the worms. Only a few hours are spent on the surface of the fruit. The worm soon begins its journey toward the core, usually starting from between the calyx lobes. In a few days it reaches the core where it spends the remainder of its caterpillar life which in all is 20 to 30 days. A single fruit may have several worms.

On coming to maturity, the worm bores to any part of the surface and leaves the fruit. It seeks a place of seclusion—a crevice in the bark, among old rubbish, or, if in a fruit box, often in a corner—and spins a cocoon around itself, inside of which it transforms to a pupa. If early in the season, it goes through the transformation from a worm to a moth immediately and lays eggs for another brood; but if too late, it remains as a worm till the following spring when it completes its transformation.

In spinning the cocoon any foreign matter at hand is woven in among the threads. The color then is dependent somewhat upon the color of the foreign matter incorporated.

NUMBER OF BROODS.

It is impossible to state definitely how many broods the codling moth would produce in Montana should it get a foothold here. West of the range there probably would be two full broods and possibly a partial third, while east of the main range there probably would be one and a partial or full second.

THE FRUIT IT ATTACKS.

The codling moth is chiefly an apple pest, though it is very destructive to pears also. It has been found feeding on quinces, crabapples and stone fruits.

HOW INTRODUCED INTO MONTANA.

It is a fairly well established fact that the codling moth was introduced into America from Europe in packages of fruit in the early days of our nation, and beyond doubt it was introduced into Montana in the same way from other states. Wherever the pest is present in an orchard it is almost sure to be gathered and distributed with the fruit. On reaching full growth, it seeks a suitable place to transform and often finds a corner to its liking in the package. The insect is thus furnished excellent quarters for completing its transformations to the moth stage, when, having wings, it seeks out any fruit trees in the vicinity. Some fruit growers in Montana have been in the habit of getting second hand boxes, after they are emptied of their imported fruit, and carrying them to their orchards to be refilled, thus affording the moth every facility for infesting their own trees. This practice is now prohibited by law and fruit dealers are compelled to destroy their boxes as soon as emptied.

Under the system of inspection of fruits and nursery stock provided for in our law, fruit infested with this or any other dangerously injurious insect is condemned and destroyed by burning. This law has been in operation only one year, but the fruit received into the state is already greatly improved in character, a wholesome fear of our laws having been instilled into the minds of shippers the country over. Thus the danger of infestation from this pest is being reduced to a minimum.

IS THE PEST LIABLE TO DIE OUT IN TIME?

It is a well known fact that many injurious insects after being introduced into a new locality and becoming well established die out of themselves through being preyed upon by natural enemies. Experience has shown, the world over, that wherever the codlin moth has once become established it has remained as a permanent scourge. Now that the pest has established itself in Missoula, Thompson Falls and Helena, we must make up our minds that Montana fruit growers will have to be constantly on the lookout for it in the future. Spraying will have to be much more generally practiced than hitherto. The codling moth is with us to stay, but by prompt and thorough use of remedies, fighting it when it first appears in an orchard, it can be held down so that Montana's loss from it will be small compared with that in other states.

NATURAL ENEMIES.

Many natural enemies among birds and insects have been recorded by different authors as preying upon the codling moth; but in spite of all, it is able to more than hold its own.

HOW TO FIGHT THE PEST.

Since Montana is only slightly infested, we can attack only the larval or worm stage to advantage. In future years it may be well to trap the moth at the windows of rooms used for storing fruit in the winter. Experiments by Forbes and Monson have shown that about 82 per cent of "wind fall" apples are produced by the codling moth. Le Baron, Cook and Beal were led to conclude by their observations that about one-half of the wormy apples that fell still contained the worms. The worms do not remain in the apple long after they have reached the ground. It is readily seen, then, that a prompt gathering and immediate destruction of fallen apples would considerably reduce the numbers of the pest. The fruit should be gathered as often as practicable, and it may be fed to animals, provided it is eaten immediately.

If the worm leaves the fruit before it drops to the ground or is picked, it preferably seeks some sheltered place, as a crevice in the bark, before spinning its cocoon. More than a century ago this fact was known and later led to the employment of trap bands applied to the trunks of the trees. To this day this method has been one of the most effective ways of killing the worms. The larva, in seeking for a secluded corner, finds one under the band. A condition necessary to make this method effective is that the rough bark be made smooth by scraping.

Any cheap and convenient substance may be used for a band. Old carpeting, burlap, paper and hay ropes have been found to be serviceable. The bands should be put or about a month after the blossoms fall and should be examined at least once in ten days and the larvae and pupae destroyed. The regular examination should not be neglected or the moths will develop and fly away in well founded derision for the bands. In badly infested orchards great numbers may be captured by the use of bands. This method catches the worms which have escaped destruction by spraying and hence is very important. Though a band may catch but very few worms in a season, its employment is still profitable.

While the above methods are important in their places, nothing can take the place of spraying. The worms caught by gathering fallen fruit and employing bands have already done their work. It is better to get them before they have begun their destruction.

It is to be urged that all orchards infested in any degree be sprayed with some arsenical poison Recommendations based on experiments with the pest in this state cannot be made. It has been found in such small numbers that experiments would give doubtful results. Probably the best spray that we can employ is Paris green, used at the rate of one pound to 160 gallons of water. It is not advised to dilute the poison with the fungicide, Bordeaux mixture, since no destructive fungus disease has yet been detected on apples in this state. Many authors advise the addition of two pounds of freshly slaked lime to the above formula for Paris green. The spraying should be given immediately after the fall of the blossoms. Three or four other sprayings should be given at equal intervals through the season. Until we find a badly infested orchard on which to experiment for the purpose of accurately adapting remedial measures to Montana conditions, more explicit direction cannot be given.

Prof. Slingerland has emphasized the importance of spraying for this insect before the calyx lobes become drawn together. It is desirable to do so, since many of the young worms take their first meal in the seclusion afforded by the closed calyx lobes, and, if poison is present, get a fatal dose. To get the best results from the spray, therefore, apply it before the lobes of the calyx have closed.

Tent Caterpillars.

(*Clisiocampa spp.*)

A few complaints of the presence of tent caterpillars have been received from different parts of Montana. The complaints not being accompanied by specimens of the insects, I am unable to state what species occur in the state. Four or more species (C. constricta, C. erosa, C. pluvialis and C. Californica) are found in the Pacific states, west of us, and it is probable that at least one of these is in Montana. On May 7th of this year, three nests of newly hatched caterpillars of some species of Cliscocampa were obtained from wild rose at Bozeman. These are being reared at the station, but at the present writing are too small for identification.

The two common species of the east are C. Americana, which is very common and injurious on apple and wild cherry, and C. disstria, which is more liable to feed on forest trees. The species which is troublesome on fruit trees in our state is probably C. constricta.

Within certain limits the larva of all these species resemble one another, and the accompanying reproductions from photographs of caterpillars of C. Americana, give some idea of the appearance of the other species. (Figures 2, 3 and 4.)

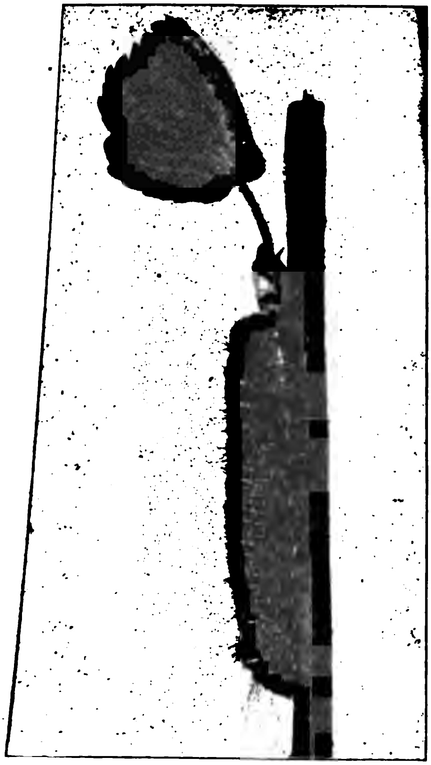


Figure 2.—Full grown larva of Clisiocampa americana. (Lowe. Bull. 152, N.Y.Agl. Exp. Sta.)

The moths are on the wing in the middle and latter part of the mmer and lay their eggs in masses on the twigs, as shown in Figure 4. ıese eggs hatch the following spring about the time the new foliage appears, d the young caterpillars migrate to the leaves and begin feeding. The "tent," familiar to all, is found at the ends of branches, or in a crotch, and is a place of retreat for the caterpillars during the night and the cooler parts of the day till they are nearly full grown. During the heat of the day they venture out and feed. The nests of the western species are not as large and as prominent as those of C. Americana of the east.

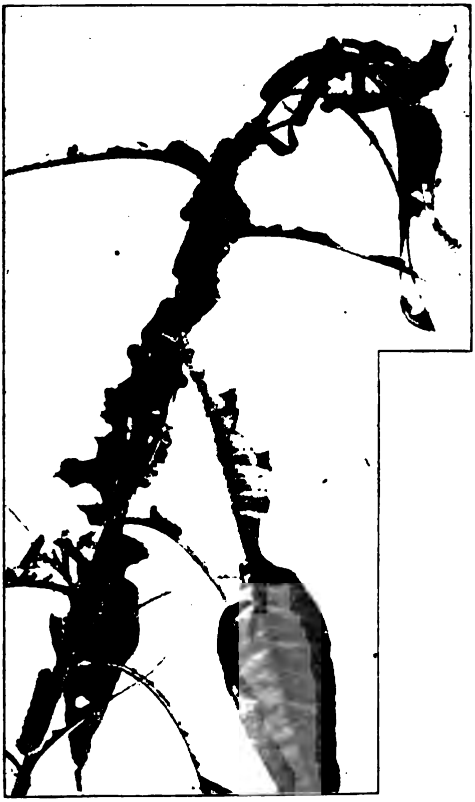


Figure 3.—Tent caterpillars (Clisiocampa americana.) feeding on peach (Lowe. Bull. 152, N. Y. Agl. Exp. Sta.)

REMEDIES.

The best way to keep fruit trees free from these insects is to search for and destroy the egg masses during the fall and winter when the foliage is off the trees. Some egg masses will escape detection but the caterpillars hatching from them may be easily destroyed when congregated in their nests at morning or early evening. It is not necessary to break off the branch or burn the caterpillars with a torch if within reach from the ground. They may be

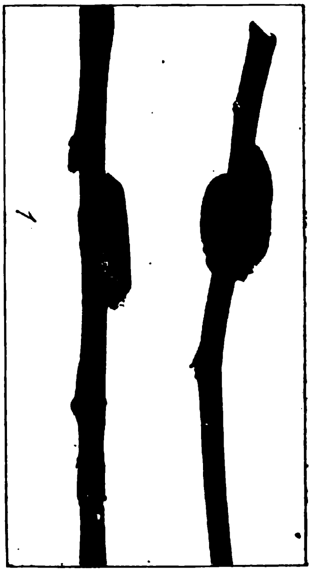


Figure 4.—Egg masses of Clisiocampa americana. (Lowe. Bull. 152, N. Y. Agl. Exp. Sta.)

destroyed with the hands. If out of reach they may be destroyed with a torch or gathered on a brush-ended pole.

The Gooseberry Fruit Worm.

(*Dakruma convolutella Huber.*)

This insect appears to be quite generally distributed in the state. It was found infesting about half the fruit on a few garden bushes in Missoula county, and has been reported from other parts of the state. While gooseberries are not grown to any great extent in Montana, the few that are produced are highly prized, and it is desirable to know the habits of the insect and the remedies to be employed.

APPEARANCE AND LIFE HISTORY.

The eggs are deposited by the female on the young gooseberries and soon hatch into minute larvae, which bore into the fruit. Sometimes several berries are fastened together by a worm. Affected berries turn color prematurely and either decay and drop off, or shrivel and dry. When the berries approach full size, those which have worms in them may be distinguished by a careful examination. A little later many of them will be seen to have a hole on the side, indicating that the worm has left or is about to leave. On leaving the berry the insect spins a silken thread and lowers itself to the ground, or crawls down the stem and spins a cocoon in which it transforms to a moth. Without much doubt, the insect passes the winter in a cocoon, as does its near relative, the codling moth. It will be noticed that throughout its life history the habits of this insect are remarkably similar to those of the codling moth. Different stages the insect are shown in figures 5 and 6.

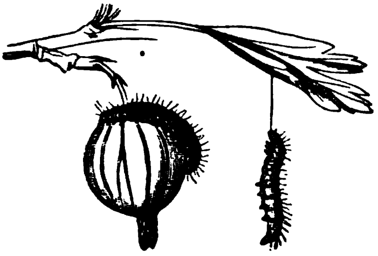


Figure 5.—Gosseberry fruitworm; larvae

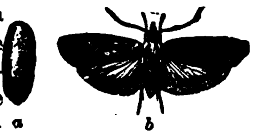


Figure 6.—Gooseberry fruit worm: a. cocoon; b, moth (After Packard.)

REMEDIES.

The insect may easily be kept under control by examining the bushes from time to time during the season in which the berries are developing, and picking off those which are colored or bound together by the silken threads produced by the larvae. Care should be taken to see that the worms do not escape, as they often work their way out of the berries when disturbed and let themselves down by a thread. Following this method thoroughly will prevent the insect from multiplying to troublesome numbers.

The Pear Slug.

Eriocampoides limacina (*Retz*)

HISTORY AND DISTRIBUTION.

The pear slug has been known in this country for upward of a century and has figured as one of the more prominent fruit pests. For many years it was thought to be the same species as the insect of similar habits in Europe, but was never demonstrated to be such until the year 1897, when Mr. C. L. Marlatt compared specimens from Europe with abundant American examples and found them identical. In Europe, the insect has been known since very early times as a particularly destructive pest.

Previous to the year 1897 nearly all American accounts of the pest were based on an excellent treatise by Prof. William D. Peck, entitled "Natural History of the Slug Worm." The essay was printed by the Massachusetts Society for the Promotion of Agriculture in the year 1799, and the author was awarded the society's premium of $50 and a gold medal. This paper has long been out of print, but Dr. Harris, in his "Insects Injurious to Vegetation," condensed it so that its substance has since been available. Mr. Marlatt's paper (Circular No. 26, Second Series) made valuable additions to our knowledge of the insect, and his illustrations are particularly useful. The history, habits and description of the insect in the following account were taken chiefly from the above mentioned sources.

The insect occurs throughout Europe, America and in many of the British colonies. In Montana it has been reported feeding on pear and cherry in or near Missoula but I have personally seen no indubitable evidence of its occurrence here.

FOOD PLANTS.

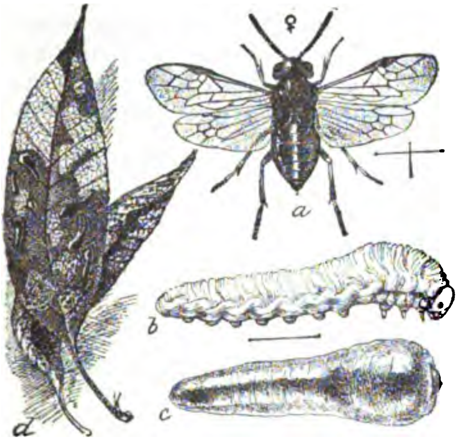
The insect feeds on pear, cherry and plum, and to a less extent on about thirty other plants. It shows a preference for pear.

INJURIES.

The slugs feed on the upper surface of the foliage, leaving a net work of veins and the lower cell layers. The leaves thus affected soon turn brown, die, and drop off. It frequently happens that the insects occur in such numbers as to wholly defoliate a single tree or a whole orchard. A second growth of leaves is at once put out and the trees are thereby seriously weakened and rendered much less liable to produce fruit the following season. The presence of the insects year after year may kill the trees or prevent fruitage. When the slugs are very abundant a repulsive odor is given off from the trees.

DESCRIPTION AND LIFE HISTORY.

In early spring the slug-fly may be seen about the trees, where they gather for the purpose of laying their eggs. The adult insect is a small glossy black fly with four transparent wings which have a dark band across the middle. The eggs are laid singly on the under side of the leaves under the epidermis. The young slug which hatches from the egg is at first clear or white with a yellow head, but very soon a slimy olive colored liquid begins to exude over the entire surface of the body. This slimy substance gives them somewhat the appearance of slugs or soft snails and has given them their common name. The front part of the body is much swollen. They at once begin to feed and eat out small patches which increase in size and unite with those of other individuals till much of the upper surface is removed. After reaching full growth the larva crawls down the stem of the plant and, burrowing into the ground for a short distance, forms a cell or chamber within which it transforms to a pupa, emerging as an adult insect about two weeks after the larva enters the ground. The last brood of the season remains in the ground till the following season.



Figuae 7.—Pear Slug: a. adult saw-fly, female; b, larva with slime removed; c same in normal state; d, leaves with larvae. natural size; a, b, c, much enlarged. (Marlatt, Circular. 26. Second Series. Div, of Ent , U. S Dept. Agr.)

REMEDIES.

The best means of destroying the insect is to spray with an arsenical poison or a soap solution. Mr. Marlatt recommends that one-half pound of whale oil soap to one gallon of water, or Paris green at the rate of one pound to 250 gallons of water be employed as a spray. Hellebore is also effective but can be employed only on a limited scale on account of its expense.

Round-headed Apple-tree Borer.

Saperda candida Fab.

DISTRIBUTION.

Published records show this insect to be present in nearly all apple growing states east of the Rocky mountains. So far as is known, it does not yet occur in Montana, but there is probably no reason why it might not become as injurious in this state as elsewhere.

NATURE OF INJURY AND IMPORTANCE.

Affected trees assume a sickly appearance and fail to make the proper growth. On the trunk may often be seen masses of castings at the openings into the insects' burrows. In some parts of the country, particularly the older fruit growing sections, this has been one of the worst enemies with which the grower has had to contend.

Besides attacking the apple it is found in various other woody plants, including crab-apple, quince and pear.

Experience has shown that trees are much more liable to be attacked if weeds, grasses or other vegetation are allowed to accumulate about the trunks.

LIFE HISTORY AND DESCRIPTION.

In the spring of the year, about the month of June, the adult beetles come forth from the trunks of the trees, the sexes mate, and the females deposit eggs as near the ground as possible. In about three weeks the

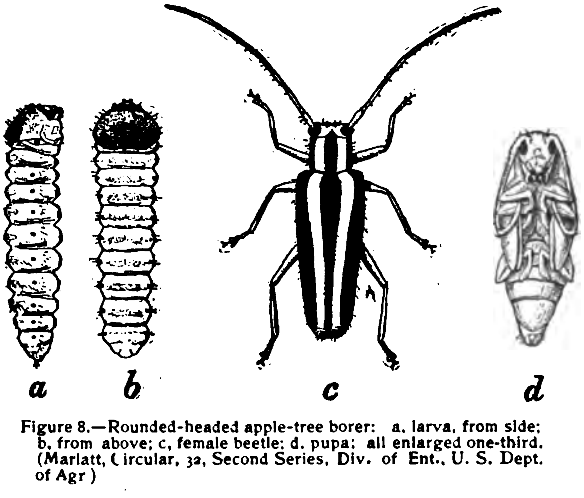


Figure 8.—Rounded-headed apple-tree borer: a, larva, from side; b, from above; c, female beetle; d, pupa; all enlarged one-third. (Marlatt, Circular, 32, Second Series, Div. of Ent., U. S. Dept. of Agr.)

eggs hatch and the larvae work their way under the bark and feed on the sap wood for the first season. During the second year they feed in the deeper heart wood, and in the spring of the third year bore to the surface, transform to pupae, and later to beetles which emerge during the night ready to lay eggs for the next generation.

The insect takes its name "Round-headed" Borer from the shape of the anterior part of the body of the larva or borer. The head is horny and brown; the body is white or yellow and tapers from the head backward to the extremity. The different stages of the insect are illustrated in Figure 8.

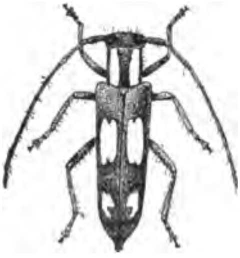


Figure 9.—Spotted apple-tree borer: female beetle enlarged one third. (Marlatt, Circular, 32, Div. of Ent., U. S. Dept. of Agr.)

The adult beetle is a beautiful creature, measuring from three-fourths of an inch to one inch in length. The under surface of the body is silvery white, while above it is brown with longitudinal white stripes.

Another borer very similar to the round-headed apple tree borer, and known as the "Spotted Apple-Tree Borer," is illustrated in Figure 9. This insect in some places is as common and destructive as the first named species. The habits and methods to be employed in their control are the same for both species.

METHODS OF CONTROL.

No spray will reach the borers. Cutting them out with a knife or other instrument is the only way of destroying this form of the insect.

After locating their burrow, by removing the surface bark with a sharp knife, a very effectual means of destruction is to use a piece of soft wire of sufficient length to reach the extremity of the burrow. Oftentimes these burrows almost girdle the tree. It is much better to prevent the beetles from depositing their eggs on the trees. This may be accomplished by applying a wash which will repel the beetles. Whale oil soap reduced to the consistency of soft soap, or soft soap itself may be used for this purpose. The entire trunk down to the very base of the tree and up even to the larger branches should be thoroughly covered. No injury will result to the tree from the application of the soap. Care should be exercised to make the application of the wash early enough in the season to be ahead of the insects.

The Flat-headed Apple-tree Borer.

Chrysobothris femorata Fab.

DISTRIBUTION AND NATURE OF INJURY.

This insect is much more often met with than the round-headed borer, but its injury is much less serious. It inhabits Canada and the United States, and is a native American insect. It is said to occur in Montana, but personally I have seen no specimens. If it is not at present among us there is little doubt that it soon will be.

There are numerous other beetles of the same family ("Buprestidae") which might be easily mistaken for it.

Trees in young orchards are much more liable to be attacked than older and stronger ones, and it seems to prefer diseased trees. It occurs in all parts of the tree.

FOOD PLANTS.

Very many shade and forest trees are attacked as well as apple, pear and peach among fruit trees.

LIFE HISTORY AND DESCRIPTION.

The female deposits its eggs in nooks and crevices in the spring and early summer. The larva hatching from the egg bores under the bark and excavates cavities of varying shape and depth in the sap wood. It very often girdles a small tree, and before pupating bores deeper into the wood. The larval life lasts for from one to three years according to Dr. J. B. Smith. The pupa stage is passed just under the bark, and the adult bores to the surface on leaving.

The work of this species may be distinguished from that of the round-headed borer by the fact that the latter, in leaving the tree, bores a circular hole, while the flat-headed species makes an elliptical one.

The appearance of the larva, pupa and adult is well represented in the accompanying illustration. (Figure 9). The insect takes its name from the appearance of the anterior part of the body of the larva. The larva is yellow and when full grown measures about an inch. The beetle is about one-half inch long and metallic brown in color on the upper surface.

Woodpeckers are very useful in destroying the larvae of the pest.

REMEDIES.

The remedies suggested for the round-headed borer may be employed against this species. The washes should be applied, however, farther out on the branches. Mr. F. H. Chittenden, one of the assistants in the Division of Entomology, at Washington, D. C., has suggested the use of trap wood to allure the beetles away from fruit trees. (Circular No. 32, Second Series). A few limbs or trunks of trees that are known to be attacked freely by the species may be laid among the rows where the sun can shine brightly upon them. This insect, unlike the round-headed borer, prefers to lay eggs on wood that is exposed to the sun. The beetles would probably lay their eggs on the trap wood, which may be gathered and burned in the fall or spring.

The Plum Curculio.

Conotrachelus nenuphar Herbst.

HISTORY AND DISTRIBUTION.

The plum curculio is a native American insect, and is particularly abundant east of the Rocky mountains. It has not yet become a serious pest on the Pacific slope, if, indeed, it occurs there at all. This is probably due to certain climatic conditions, and, since the climate in the fruit growing regions of Montana is somewhat similar to that farther west, the insect may never be troublesome in this state. It has not yet been reported in Montana.

INJURIES.

Montana fruit growers should be on the lookout for this insect and promptly report its occurrence if found. In many sections, plum growing has been abandoned on account of this small, but destructive insect. Its importance is increased by its fondness for other fruits besides the plum.

FOOD PLANTS.

Besides attacking the plum, the insect breeds in great numbers in cherries, peaches, apricots, nectarines, quinces, apples, crabs, and haws.

DESCRIPTION AND LIFE HISTORY.

The insect hibernates as an adult beetle and appears early in the spring When the fruit has reached about the size of a small marble, the beetle makes a crescent shaped slit in the epidermis (see Figure 11 d.), elevating a small flap under which it lays an egg. In a few days this egg hatches into a small white grub which at once bores to the seed capsule causing the fruit to fall in the case of the plum, but simply to decay from the center in most other fruits. By about midsummer growth is complete and the larva enters the ground for a short distance and soon after appears as an adult beetle. The beetles very soon go into hiding till the following spring.

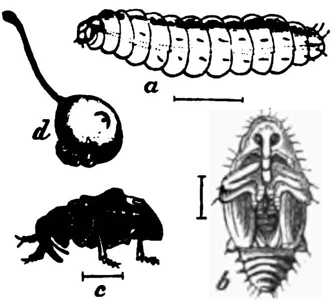


Figure 11.—Plum Curculio: a. larva: b, pupa: c, adult: d, beetle at work on a young plum showing a crescent mark. (After Riley.)

The beetle is less than one-fourth of an inch in length, brown with black and gray mottlings and with four protuberances on the wing covers.

REMEDIES.

There is no known satisfactory remedy for this insect. The larva cannot be reached with an insecticide and can be destroyed, only by gathering the fallen fruit every few days. Chickens and turkeys, if given free run under infested trees, gather large numbers. Jarring the trees occasionally early in the mornings over a sheet or other receptacle has given more uniform satisfaction than any other remedial measure. The beetles drop readily, and, drawing in their legs, allow themselves to be gathered up and destroyed.

The San Jose Scale.

(Aspidiotus perniciosus Comst.)

DISTRIBUTION.

The San Jose scale, now so well and unfavorably known, is very widely distributed in the United States and occurs in many foreign counries, including Canada, Australia, Japan, Chili and Hawaii.

NOT FOUND IN MONTANA.

The insect has not yet been detected on plants growing in Montana, though the inspectors working under the direction of the State Board of Horticulture have searched nearly every orchard in the state.

ITS POWER OF INJURY.

The San Jose scale is capable of causing great loss if allowed to pursue its course unchecked, and its presence in an orchard makes constant watching necessary lest it get out from under control. Its minute size and inconspicuous appearance enable it to escape easy detection, and the orchardist or nurseryman who knows his premises to be infested is kept in constant terror. It not infrequently happens that an orchard is ruined or injured beyond repair before the owner is aware even of the presence of the pest. Some states in the Union have suffered more severely from this insect during the past few years than from any other. In more southern ranges of our country whole orchards have been destroyed. Considering that it attacks practically all kinds of fruit, it probably ranks as one of the worst fruit insects in the United States. In Montana, where the apple is by far the most important fruit, the codling moth may properly be ranked of more importance. It is greatly to be hoped that our trees may be spared from infestation.

The Montana State Board of Horticulture is making special effort to keep the insect from entering the state. All nursery stock crossing our borders is submitted to a fumigation and at the main receiving points for green fruits a rigid inspection is given and any badly infested stock is destroyed.

WOULD THE INSECT THRIVE IN MONTANA?

I have often been asked if the San Jose scale would become a serious pest in our Montana climate should it gain admittance. The question can be conclusively answered only after experimenting. It occurs quite commonly in Canada and is a bad enemy to fruit culture in Oregon, where conditions are not very materially different from those west of the range, at least, in Montana. While there may be some doubt that the pest would be a serious menace to Montana fruit trees, we prefer to keep the benefit of the doubt. We could not afford to slack our vigilance even if there were but one chance in fifty that this scale would prove to be a serious enemy in Montana. Every effort should be made to keep the San Jose scale out of our state.

APPEARANCE OF THE INSECT.

The ordinary observer will not usually detect the San Jose scale in an orchard until it has multiplied to such numbers as to be a serious injury to the trees. Affected trees take on a sickly appearance, fail to make the proper growth and have foliage less brilliant than the normal. Such trees should be carefully examined, and if infested with this pest will be found to be covered with the gray, scurfy scale of the insect. Anything doubtful should be sent to the Experiment Station for examination.

Orchardists not infrequently become alarmed at the presence of grayish or yellowish specks distributed sparingly and evenly over the bark. These are the lenticels, or breathing pores, and are present on all healthy fruit trees.

HABITS AND DESCRIPTION.

In their excellent bulletin on this insect, Dr. L. O. Howard and Mr. C. L. Marlatt (Buletin No. 3, New series U. S. Dept. Agr., Div. of Ent.) have given a detailed account of its life history. This account has been the basis of all subsequent accounts of the kind, and the facts of its life history as given below are taken from the same source.

In all armored scales, including the San Jose scale, the insect spends all but a few hours of its existence attached to one spot on its host-plant, and covered by a more or less convex scale made up of a "waxy" secretion produced from glands in the body, together with the more or less easily distinguished molted skins cast off by the insect from time to time as it increases in size.

The San Jose scale lays no eggs, as do many scale insects, but produces young larvae direct, ready to crawl off almost immediately. The young larva is almost microscopic in size, orange yellow in color, and provided with six legs, two antennae and a pair of eyes, visible from above, and on the under surface it possesses a long, thread like proboscis. It soon crawls out from under the parent scale and, after wandering about for a few hours, comes to rest, and, inserting its proboscis, begins to feed. The adult female produces young over a period of about six weeks, during which time from a few to something like five hundred are born. The average number is about four hundred.

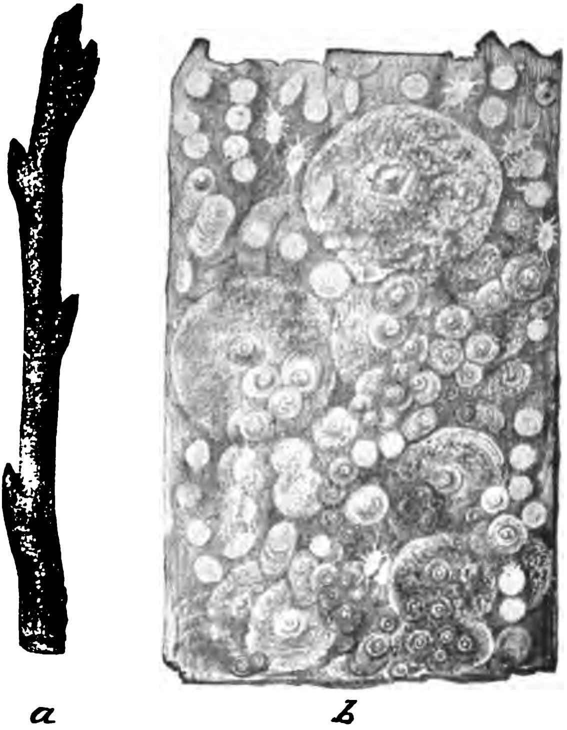


Figure 12.—San Jose Scale: a. infested twig natural size: b. as the scales appear under a hand lens (Howard and Marlatt. Bul No. 3. New Series, Div. of Ent., U. S. Dept of Agr.

It is impossible to state accurately at what date the young would appear in Montana but we may safely say that it would be ta abou tth etime the leaf buds unfold, or a little earlier.

Very soon after the young larva comes to rest the scale may be seen to assume shape. For a time the scales of the two sexes cannot be distinguished from each other but the male scale is completed long before the female. The mature male scale is oblong-oval, its length being equal to about half the diameter of the female scale, black or grayish, and having in the center a nipple like prominence.

Within this scale the male larva changes to an adult winged form, an illustration of which is given in figure 14. It is orange colored. Backing out of its scale it goes in quest of the female which by this time is about half grown. After impregnation the female increases rapidly in size and at from thirty-three to forty days after birth begin to produce young.

The female is circular, slightly convex and gray or blackish sometimes of a yellowish tinge. The central part is yellowish or reddish. It is about one twenty-fifth to one twelfth of an inch in ameter.

The number of broods varies in different parts of the country dependent upon the climate. Dr. Howard and Mr. Marlatt found that at Washington there were about four or five broods. In Montana there would doubtless be fewer.

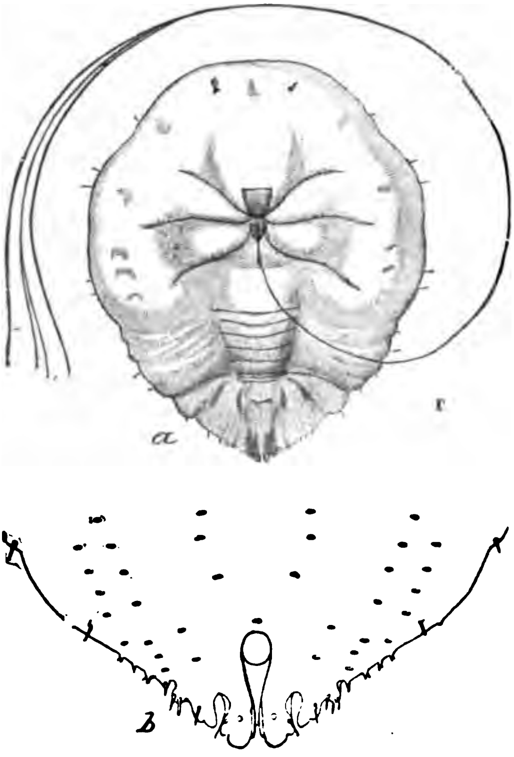


Figure 13 — San Jose Scale: a, adult female showing very long sucking setae; b. anal plate showing characteristic ornamentation of edge: greatly enlarged. (Howard and Marlatt, Bul. No. 3 Div. of Ent., U. S. Dept. of Agr.)

The insect passes the winter as a partly grown impregnated female, the male having died in the fall. In the spring she resumes feeding, completes her growth and begins producing young. Not all resume activity at the same time and this fact and the length of time during which the female produces young have a very important bearing upon their treatment with remedies. In many egg producing scale insects the young are hatched almost simultaneously and may be found swarming over the bark. One or two sprayings with a moderately strong insecticide will kill nearly a whole brood of such an insect but with the San Jose scale where the young are produced throughout the season, many more applications are necessary—so many that it becomes impracticable to control the insect by attacking the larval stage

alone. This is one reason why the San Jose scale is so hard to control.

METHOD OF INJURY.

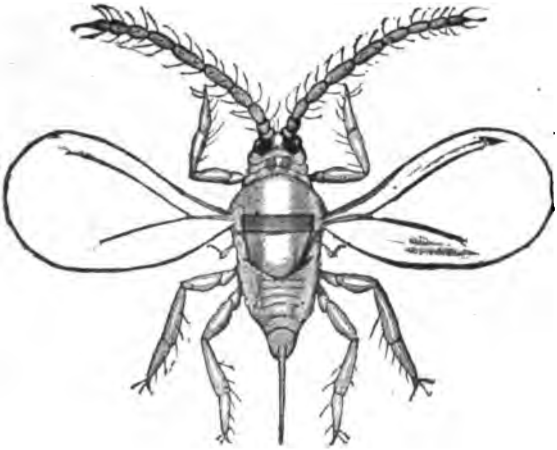


Figure 14.—San Jose Scale: adult male. (Howard and Marlatt, Bul. No. 3, Div. of Ent., U. S. Dept, of Agr.)

It is a source of wonder to many people that insects so small as the San Jose scale can overcome a tree. When we consider how immensely prolific the species is and realize that the life of a tree rests just under the bark, we can easily see that the death of a tree may be readily brought about. Their accumulated numbers settling upon the bark first weaken the tree and finally lead to its ruin. Morever it is not necessary that a tree be entirely killed to be rendered useless.

The insect attacks all parts of the tree—bark, leaves, roots and when abundant even the fruit. On fruit it often causes a reddening of the immediately surrounding parts. While this aids the eye in detecting the insect on fruit it cannot be depended upon to distinguish the San Jose scale from other diseases.

MEANS OF DISTRIBUTION.

The female San Jose scale does not possess wings at any time of its life and is without legs except during the few hours of larval existence. The young larva is of microscopic dimensions and is incapable of migration for any great distance. The insect, is, therefore, practically incapable of spreading by its own means. It is often carried for some distance on the bodies of other insects and of birds. Winds also dislodge the larvae and carry them for a considerable distance. None of these methods however will account for the almost world wide distribution of the species. In very many cases its presence in distant orchards and nurseries has been directly traced to imported nursery stock. This is undoubtedly the chief means of distant distribution of the pest. Infestation has also been traced to parings of infested fruit being thrown where larvae developing from them could rech suitable vegetation.

FOOD PLANTS.

The San Jose scale attacks nearly all deciduous and citrus fruit trees,

and also many garden shrubs and shade trees. It is most severe on fruit trees.

NATURAL ENEMIES.

Several true internal parasites have been taken feeding on this scale insect, and are very efficient aids in keeping it in check.

Several lady-bird beetles feed upon the insects destroying great numbers but we cannot look to either class of enemies to exterminate the insect.

METHODS OF TREATMENT.

All trees known to be infested should be dug up and burned; there can then be no question that the insects are destroyed. All other trees in the same or neighboring orchards should be treated with one of the washes mentioned below. Should the state, or any part of it, ever get so badly infested that eradicating the pest would be out of the question it would then be more advisable to dig out only the worst affected trees and treat the rest with a wash.

Whale oil soap has been for a number of years, and is still, the safest and best all round remedy for the scale. The first experimenting with the substance as a remedy for this insect was done by Dr. Howard and Mr. Marlatt and recorded in Bulletin No. 3, Div. of Ent., Dept. of Agr. The soap should be diluted in water at the rate of two pounds in one gallon. Using hot water facilitates bringing it into solution and it should be applied while still hot. It may be applied as a spray or with a brush or rag. It can be used with safety to the trees only between the time the leaves drop in the fall and the buds swell in the spring. If thoroughly applied twice, the greater part of the scales will be killed.

The wash most commonly used in the Pacific states is the lime, sulphur, and salt solution. This is employed only as a winter wash and is applied once in the fall after the leaves drop and once in the spring before the buds swell. This wash, though of great service in California, Washington and Oregon, has been found to act very differently in the eastern part of this country, being almost without effect on the scale. There seems to be reason, therefore to question whether the wash would be effective in Montana. If opportunity is presented it would be well for different individuals to test the wash in this state.

Kerosene is now being used for this and other scales but with varying results. At the annual meeting of the American Association of Economic Entomologists held at Buffalo, N. Y., in August, 1896, Professor F. M. Webster reported that undiluted kerosene had been used in two orchards near New Richmond, Ohio, with marked success and without the least injury to the apple and peach trees, to which it had been applied. The statement was received with much surprise and interest and a number of entomologists present soon began experiments in their respective states. Much has been published on the subject since that time and strikingly different results have been recorded. In some cases kerosene has been found an excellent remedy, all scales being killed without injury to the trees while in other cases it has destroyed insect and tree together. The cause for this confliction in results is not fully understood. Experiments have shown that the trees are less liable to injury if the spray is very fine, and applied during a bright day in winter, care being taken that none is allowed to run down the trunk and collect at the base. Even with these precautions the treatment is not always safe. If the substance could be used without danger of injury to the trees it would be by far the best remedy. Anybody desiring to try the substance should first experiment on a few trees of different kinds. It should be used only while the trees are dormant and the results should be studied for a full season.

Trees should be pruned back before applying any of these washes.

A comparatively recent method of treating for San Jose scale and other insects is that of fumigation with potassium cyanide gas, commonly called hydrocyanic acid gas. The San Jose scale has no egg stage and passes the winter as a partly grown insect. The gas therefore is fatal to the insects whenever applied.

The essential principles of fumigation are given in Part II. For the treatment of nursry stock either an air tight enclosure or a tent constructed for the purpose may be used.

The Oyster-shell Bark-louse.

Mytilaspis pomorum Bouche.

DISTRIBUTION.

It is probable the oyster-shell bark-louse came originally from Europe. It is now found all over the world and is the best known of any of the orchard scales. It was probably introduced into this country on nursery stock in the early history of our nation. Published records show it to be very widely distributed in the United States. A very few cases of infestation have been found in Montana by the inspectors of the State Board of Horticulture. The state as a whole is remarkably free from the pest.

FOOD PLANTS.

The insect attacks a large number of plants including apple, pear, plum, quince, hawthorn, raspberry, currant, linden, willow, cottonwood, poplar, wild cherry, rose and white birch. Many of these plants, beside apple, it attacks so severely as to threaten their life.

LIFE HISTORY AND DESCRIPTION.

The scales of the two sexes are quite different in size and appearance. The scale of the female is elongated, broader at the posterior end than at the anterior, about one-eighth of an inch long; rounded on the upper surface flat beneath. The different stages of the insect are shown in figures 15 and 16.

If one of the female scales be turned over during the winter there may be seen a large number of very minute white eggs closely packed together, and, at the anterior end of the scale the dead and shriveled body of the insect that laid them. According to Dr. Howard the number of eggs from one individual varies from 42 to 86. With reviving nature in the spring these eggs hatch into minute larvae represented at Figure 16,c., which crawl out from under the parent scale and scurry off to find places to settle down. In more southern parts of the United States there are two broods of the insect in one season.

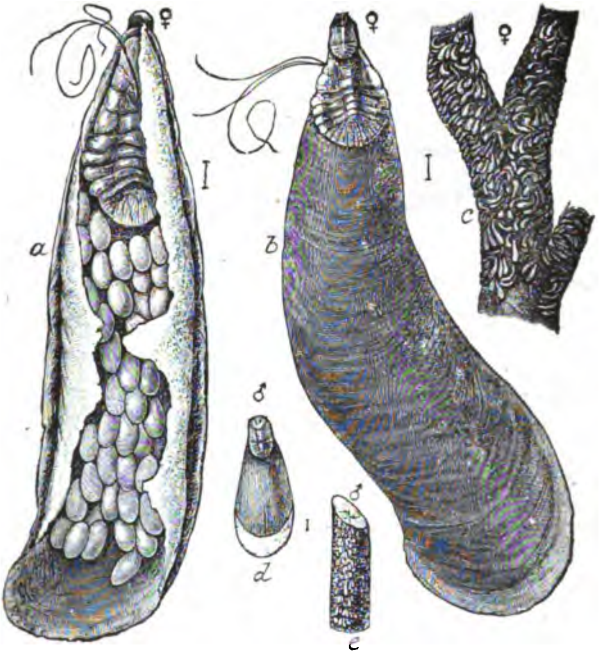


Figure 15.--Oyster-shell Bark-louse. a, female scale from below showing eggs; b, same from above greatly enlarged; c, female scales; d, male scales enlarged; e, male scales natural size. (Howard, Yearbook, U. S. Dept. of Agr.)

It is impossible to state at what time the eggs hatch in Montana; the time doubtless varies greatly in different seasons. No observation has been made in Montana to determine this point, but it is probable that the middle of June is not far from the time. The time of appearance of the young larvae is important, as this is the point in the insect's life when it is most readily reached with insecticides. The male scale is much smaller than that of the female but is of the same color.

INJURIES.

A few specimens on an apple tree or other plant would do no harm. Injury comes only through the presence of large numbers. The insect feeds by imbibing the juices of the plant; it does not devour the solid substance. In taking up the juices it injures the part of the plant immediately under it and when there are enough individuals present to cover a considerable portion of the bark their presence may be a serious menace to the tree.

The insect only rarely attacks the fruit. It is a bark infesting species. Neither this species nor the scurfy bark-louse are to be compared to the San Jose scale in importance.

REMEDIES.

The most effective remedy is to spray with kerosene emulsion diluted with nine parts of water when the young are hatching in the spring of the year. The delicate young larvae easily succumb to this treatment. A second application should be made a few days later to kill any remaining larvae. The first spray should be applied soon after the first young lice are seen. A dilute solution of whale oil soap will probably serve the same purpose.

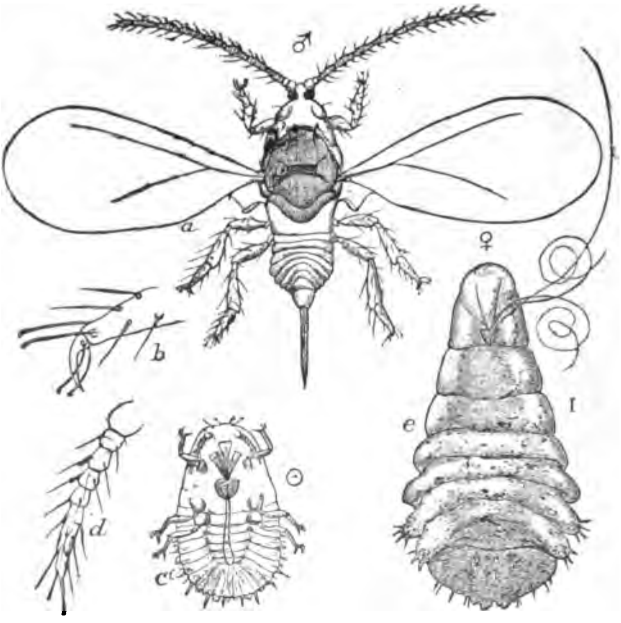


Figure 16.—Oyster-shell Bark-louse: a, adult male; b, foot of same; c young larva; d, antenna of same; e, adult female taken from scale; a, c, e, greatly enlarged; b, d, more enlarged. (Howard Yearbook, U. S. Dept. of Agr.)

The Scurfy Bark-louse.

Chionaspis furfura *Fitch.*

DISTRIBUTION.

This scale insect is a native North American species and is well known in most parts of the country. It has not yet been reported from Montana.

FOOD PLANTS.

Various authors have published this insect as occurring on apple, pear, peach, cherry, currant, crab apple, Japan quince, blackberry, choke cherry, mountain ash, black walnut and raspberry.

LIFE HISTORY AND DESCRIPTION.

The scales of both sexes are white but are very different in form and size. The female scale (Figure 17 c.) is much larger than the male (Figure 17 d.) and is more or less pear shaped while that of the male is elongated with parallel sides and possesses three ridges running down the back. The female scale is about one-tenth of an inch long.

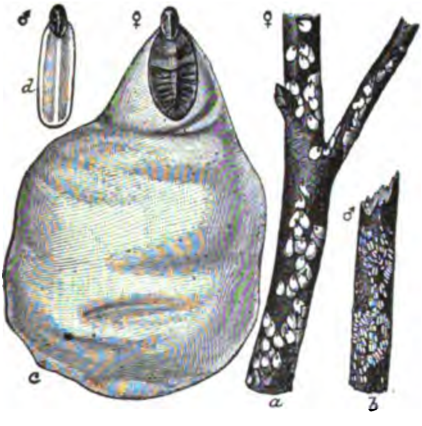


Figure 17.—Scurfy bark-louse: a, c. females; b, d, males; a, b, natural size; c,d, enlarged (Howard Yearbook, U. S. Dept. of Agr.)

As is the case of the oyster-shell bark-louse, this insect passes the winter as eggs closely packed under the parent scale along with the dead and shriveled body of the female. The insect usually lays from thirty to fifty eggs, though Dr. Howard has recorded seventy-five and they are reddish purple in color. They are deposited in the fall and hatch in most parts of the northern United States in the latter part of May and early in June. There is only one generation in the northern part of the country though it is probable that farther south two and perhaps three occur.

Usually the species confines its attack to the bark of the tree but occasionally it attacks the leaves. It seldom if ever attacks the fruit.

This species goes through the same transformations as does the species last discussed.

INJURY.

This species is usually considered to be of less economic importance than the oyster-shell bark-louse, but at times it becomes very destructive. Professor

Osborn writing of it says: "This species is at times very plentiful and destructive in our orchards and whenever seen should be promptly treated." Dr. Littner says: ""This scale insect known to science as 'Chionaspis furfurus' (Fitch), is quite common in the state of New York, where it is believed to be more numerous and more injurious than any other of the United States. I have recently seen an orchard of the Kieffer pear, in Columbia county, N.Y., in which the trunks of from three to four inches in diameter, were so thickly crusted with the scale that at a little distance they appeared as if they had been whitewashed." Numerous other cases might be cited which would go to show this to be a destructive insect at times.

NATURAL ENEMIES.

There are a number of natural enemies of this species. The twice stabbed lady bug, 'Chilocorus bivulnerus,' is thought to be very importanat in holding the scale in check. Were it not for this little friend it is very probable that orchardists would have much more trouble from this scale insect.

REMEDIES.

The remedies for this species are the same as for the oyster-shell bark-louse.

The Woolly Aphis of The Apple.

(*Schizoneura lanigera Hausmann.*)

DISTRIBUTION.

There is considerable doubt as to whether the woolly aphis is of European or American origin and the question will probably never be settled. As early as 1787 it was detected on stock arriving in England from America. In Europe it soon took the name of "American blight," which name it has held there ever since. In his very useful paper on this insect, published as a circular (No. 2, Second Series) of the Division of Ent., U. S. Dept. of Agr., Mr. C. L. Marlatt records the insect from Australia, New Zealand, India, Chili and states that it occurs practically wherever the apple is grown.

It is very widely distributed in the United States and appears to thrive both in northern and southern states. Its chief means of distribution over long distances is on the roots of plants sent as nursery stock.

OCCURRENCES IN MONTANA.

Only one case of infestation in Montana has been brought to our attention. While the writer was visiting Missoula in September 1899 Mr. M. M. McDonald pointed out a single small tree moderately infested with woolly aphis but the tree showed no injury. A few other similar cases have been said to have occurred in Montana but as yet there has been no serious outbreak.

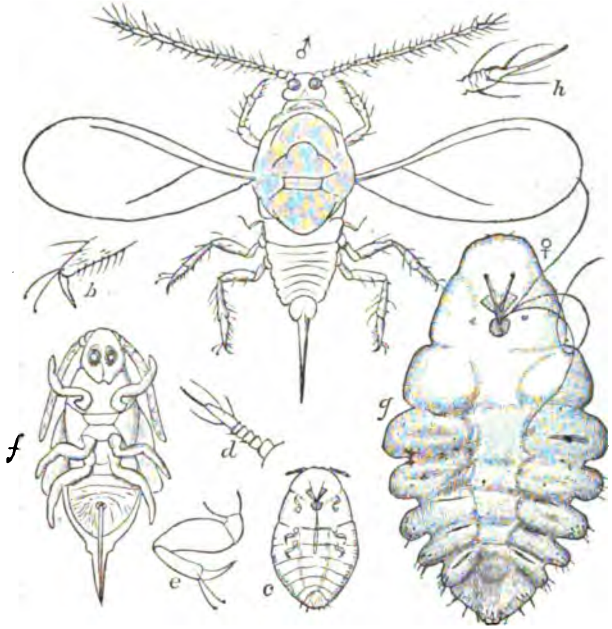


Figure 18.—Scurfy bark-louse: adult male above; c. larva; f. pupa; g. adult female removed from scale; all enlarged. (Howard Yearbook, U. S. Dept. of Agr.)

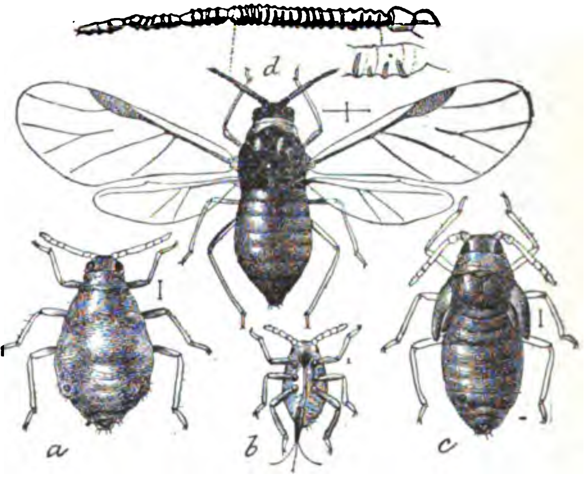


Figure 19.—Woolly aphis: a, agamic female; b larval louse, c. pupa; d. winged female with antenna enlarged above; all greatly enlarged and with waxy excretion removed. (Marlatt, Circular No 20, Second Series, *Div.* of Ent., U. S Dept of Agr.)

LIFE HISTORY AND METHOD OF ATTACK.

The woolly aphis exists in two forms, one above the ground on the water sprouts or often in partly healed wounds such as those caused by the removal of branches, and another, found only on the roots.

The aerial form appears as masses of whitish flocculent matter which when broken apart reveals the dark colored bodies of the insects. The flocculent or woolly matter is simply a secretion from their bodies. The presence of this form of the insect sometimes gives a tree a distinct whitish appearance over a part of its surface.

Attention should be called to the fact that there are aphids attacking various trees besides apple, which produce the woolly or flocculent growth from their backs. A woolly aphis is not necessarily the woolly aphis of the apple.

The root form of the insect is the one which is responsible for much the greater part of the injury caused by the species. Its attack causes the roots to take on irregular enlargements known as galls and in the cracks and corners of these galls the insects occur. See Figure 20, a, b, and c.

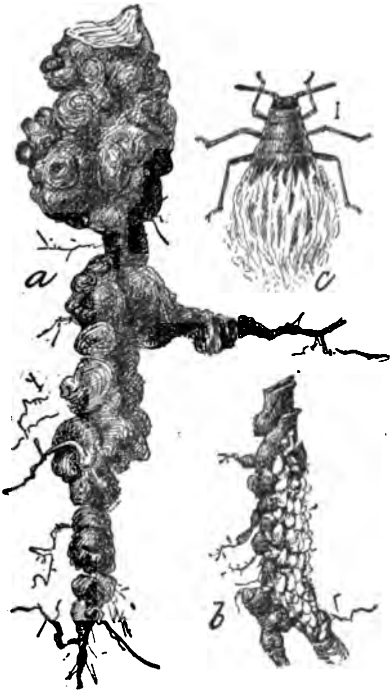


Figure 20.—Woolly aphis: a, Root of young tree illustrating deformation; b, section of root with lice clustered over it; c, root louse, female—a and b, natural size; c, much enlarged. (Marlatt Circular No. 20, Second Series, Div. of Ent., U. S. Dept. of Agr.)

The insects' attack is much more serious on nursery stock and newly planted orchards. A moderately infested tree may show no serious effects but one badly attacked assumes a sickly appearance and fails to make the normal growth. Continued attack results in death of the tree.

In the fall, winged individuals, very dark in color with more or less cottony secretion on their backs make their appearance and are a means of extension of the colony of the insect.

REMEDIES.

The desirability of preventing this insect from entering the orchard is apparent. No apple trees should be planted without first examining the roots for the galls. If the galls are numerous and large the trees should not be accepted; if few and small dipping the roots for a few seconds in kerosene emulsion diluted with eight parts of water will disinfect them. A whale oil soap solution may be used for the same purpose.

Fumigation will also rid stock of the root form of the insect. But if winter eggs of the aerial form are present they will not be affected. These eggs are so small as to usually escape detection.

The aerial form, in growing trees can be easily gotten rid of by spraying with kerosene emulsion or whale oil soap. Considerable force in the spray is necessary in order to penetrate the masses of insects.

Various methods of attacking the root form have been proposed, none of which is altogether satisfactory. Probably the best treatment is to remove temporarily the surface soil from above and apply water heated almost to the boiling point, in sufficient quantity to soak the earth nearly a foot deep. Lime, gas lime, ashes, soot, tobacco dust, tobacco solution and strong soap solutions have also been applied in the same way. Simple hot water will usually be found to be most convenient and least expensive.

The Apple Plant-Louse.

(*Aphis mali Fabr.*)

DISTRIBUTION.

The apple plant-louse, also known as the green aphis, is one of the mos common and best known fruit pests of Montana. There is scarcely an orchard which is not more or less affected. Nearly half a century ago Dr. Asa Fitch received specimens of the European insect, Aphis mali, direct from Europe and after making comparisons stated that there was left in his mind not the slightest doubt that the aphis which so commonly attacks apple in this country was the same species. Dr. Fitch believed that it was introduced in nursery stock and was doubtless correct in his opinion.

INJURIES.

This insect when abundant causes considerable injury to the tree. Usually the most apparent injury is that inflicted on the leaves which take on a curled and disfigured appearance. Not less important is the injury to the unfolding buds in the spring. Settling upon the young and tender leaves the lice seriously interfere with their growth and diminish the vitality of the tree.

FOOD PLANTS.

This insect principally attacks apple but Prof. F. M. Webster has observed it feeding on quince, grasses, wheat and other plants (Bull. 51, Ohio Agr. Exp. Sta., 1893, p. 111).

LIFE HISTORY AND DESCRIPTION.

During the winter a close examination around the buds of apple often reveals more or less numerous shiny black ellipsoidal bodies—the eggs of the apple aphis. These hatch into little green lice commonly found on apple twigs at spring. These lice give birth to others within a few days which in turn give rise to a third generation. According to Prof. Webster by about three weeks after the eggs begin to hatch winged lice appear which abandon the tree and go to grasses and probably some common weeds.

Generation after generation appears during the summer and at fall, eggs are deposited to continue the species the next spring.

The winged lice instead of being black throughout, as are those without wings, have the body black except the abdomen.

NATURAL ENEMIES.

There are many insects which prey upon the Aphis. Even the minute eggs do not escape being destroyed since two very minute parasites attack them. Great numbers are destroyed by the larvae and adults of lady beetles and the larva of the common lace wing fly, Chrysopa oculata. Very often on opening up a curled leaf infested with this aphis, small flat worms rounded at one end and pointed at the other, are seen busily picking up the lice, one by one, on the pointed end of the body and devouring the contents of the body. These are larvae of flies known as Syrphus flies. These enemies are very useful in holding the apple aphis in check. So efficient are they that the aphis seldom causes great injury except in the spring of the year before the enemies get out in force.

REMEDIES.

Picking off a very few leaves will often rid a tree of nearly all the lice upon it. Spraying with kerosene emulsion or whale oil soap is usually the best remedy for the pest when generally distributed unless it be that only a few terminal branches are attacked when simply dipping the affected parts in a pail of the insecticide is found to be more satisfactory.

It is not probable that the winter eggs can be reached without injury to the trees.

The Pear Psylla.

Psylla pyricola Foster.

ORIGINAL HOME AND PRESENT DISTRIBUTION.

In the eastern part of the United States this insect is a well known pest and has caused much destruction. It is of European origin and was imported into this country in the early part of the present century. It at once made itself known and has now spread throughout the United States east of the

630.679
M9

Mississippi river. It is little known, if at all, west of that river. It occurs in Canada.

FOOD.

In Europe it is reported to occasionally attack apple as well as pear, but in this country it confines itself to the latter.

INDICATIONS OF ITS PRESENCE.

The effects upon the tree are more noticeable than the insects themselves. In severe cases of attack but little new growth is put forth, the tree bears a weakened sickly appearance and sometimes the leaves and fruit are prematurely shed. When they are abundant large quantities of sweet watery liquid called honey dew are secreted by the insects and forms a coating over the leaves and branches. Affected trees are sometimes noticeable for an unusual number of insects flying among the branches and gathering these sweets. This same appearance often follows the attack of aphids. This honey dew soon becomes filled with a black fungus giving the tree a dirty appearance. Prof. Slingerland has observed that in the state of New York all varieties and ages of trees are attacked.

LIFE HISTORY AND DESCRIPTIONS.

We are indebted to Prof. Slingerland of Cornell for the greater part of what is known of the life history of this important insect. It passes the winter in the adult state hidden in crevices and under the loose bark of the trunk and larger limbs of the tree. On the arrival of warm weather they leave their winter quarters, the sexes mate, and the females begin laying their eggs which process is completed early in the season. The eggs are placed on the twigs often on or near the terminal and lateral buds. They may be laid singly or in rows. The eggs are very minute, measuring but one-eightieth of an inch in length. They are elongated, pear shaped, yellow at first but become darker before hatching.

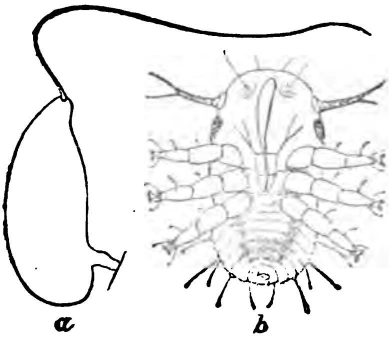


Fig. 21—Pear-tree psylla: a, egg; b, larva; both greatly enlarged. (Marlatt circular No. 7 Second Series, Div. of Ent., U. S. Dept. of Agr.)

The secluded crevices furnished by the bases of the leaves and other crevices are the favorite haunts of the young nymphs. The young are quite inactive but on reaching maturity, which occurs in about a month their strong legs and wings enable them to fly up and away very quickly.

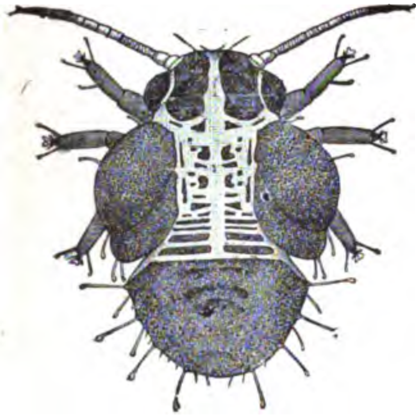


Fig. 22.—Pear-tree psylla: nymph, greatly enlarged. (Marlatt Circular, No. 7, Div. of Ent., U. S. Dept. of Agr.)

In the state of New York there are at least four broods. The eggs of the later broods are placed on the leaves and hatch in eight to ten days.

INJURY.

The insects injure the trees by extracting large quantities of sap from the bark, buds, leaves, leaf and fruit stems, not only what is assimilated as food, but what is secreted as "honey dew." It appears to be very injurious at times but a long period of years may occur in which it is but little known.

It spreads but slowly of its own accord but has been widely disseminated on nursery stock.

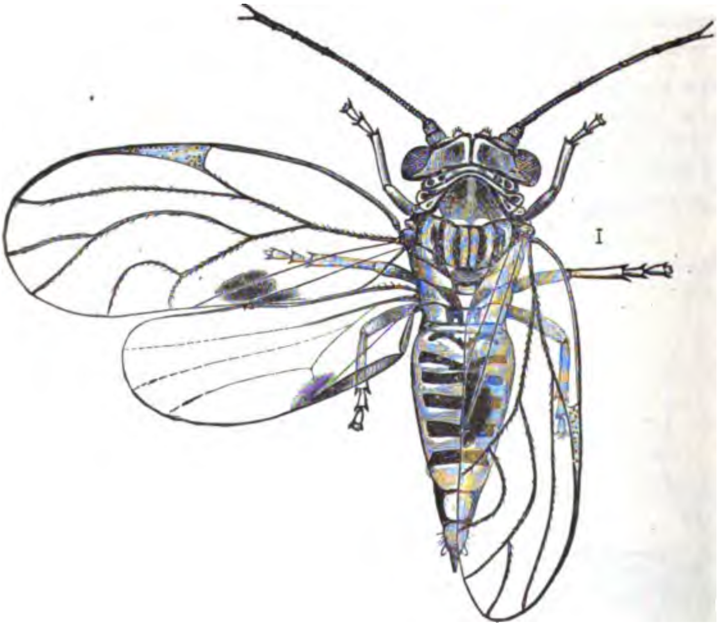


Fig. 23.—Pear-tree psylla: adult female greatly enlarged. (Marlatt Circular No. 7, Div. of Ent., U. S. Dept. of Agr.)

REMEDIES.

Prof. Slingerland found that only a part of the eggs could be killed even by dipping them in kerosene oil, turpentine, benzine and several substances used for killing scale insects. A very effective remedy for the nymphs is spraying with kerosene emulsion diluted with ten to fifteen parts of water. Prof. Slingerland states that this treatment will also kill the adult insects. The first application should be made just as the leaves are beginning to expand. A second and third spray would probably be necessary. It is to be urged that Montana fruit growers watch carefully for this pest and treat for it if it is found even in small numbers. The insects will not be killed unless actually touched with the spray so the application should be very thoroughly made.

The adults may be successfully treated in winter by an application of whale oil soap. While the kerosene emulsion spray is much more effective if applied at the very beginning of the season when the nymphs are hatching, it may also be used with success later on when the tree is in full foliage and the insect present in all stages. One thing to be urged in the use of these remedies is thoroughness.

The Tarnished Plant-bug.

Lygus pratensis Linn.

DISTRIBUTION AND INJURIES.

This insect occurs throughout the United States and extends into Mexico and Canada. A great many accounts have been written by American authors and it has been recorded as injurious to a large number of cultivated and native plants. It has been known to cause great destruction to young pear and peach trees. It feeds on nearly all farm and garden crops. The pest was reported this spring from the Bitter Root valley as very injurious to the blossoms of strawberry causing them to wither and die. Last season the species was very injurious to asters in the garden of the Experiment Station and was reported by Mr. H. C. B. Colvill as injurious to fruit trees. I have observed the species to be exceedingly abundant on grasses and weeds in the open unploughed fields of the state.

LIFE HISTORY.

The insect passes the winter in an immature condition under any convenient shelter. The eggs are deposited on the stems of plants and the young hatch and feed on the tender parts of the plant.

MEANS OF CONTROL.

This is one of those insects for which no satisfactory remedy is known.

Food is taken up through a sucking beak so that poison applied to the affected plant does not harm the insects. Contact insecticides are not very effective on account of the thick protective covering of the body. If it is once driven from a field it will soon come in again. On low growing plants like strawberry it is next to impossible to control the pest. On higher plants like nursery trees the best way of reducing their numbers is to jar them off during the cool part of the day when they are least active, catching them in a receptacle beneath. "Construct a light wooden frame about two and a half feet square, with wires from the corners to a small central ring, which should be at least 10 inches lower than the frame. Fasten to the frame and enclose the wires with a light cloth (oil cloth would be preferable) in such a manner that insects dropping upon it would roll toward the center, and be caught in a small pail or can, containing a little kerosene and water, fastened to the central ring. A short handle should be fastened to the frame for its convenient use in the nursery rows." (Dr. J. A. Lintner).

Currant Flies.

Rhagoletis ribicola Doane.
Epochra canadensis Loew.

DISTRIBUTION.

In some parts of the state, if not in all, a considerable portion of the annual crop of currants is destroyed by insects which work inside the berries causing them to prematurely turn color and later to drop off. This destruction is caused by the maggots of one or two species of flies. There are at least two species that work in this way in the United States, one known as the Dark Currant Fly (Rhagoletis ribicola Doane) and one as the Yellow Currant Fly (Epochra canadensis Loew.) which has been known for a much longer time. It has not been determined which of these species is found in Montana; it is probable however that both are present.

Prof. C. V. Piper and Prof. R. W. Doane have published a very helpful account of these insects in Bulletin 36 of the Washington Exp. Sta. It is from this bulletin that the accompanying illustrations (Figure 24 and Figure 25) are taken by courtesy of the authors. They state that both occur in Washington but that the Dark Currant Fly has been more abundant and destructive.

Both species also attack gooseberries. In 1891 Prof. C. P. Gillette found the yellow species very abundant in gooseberries in Colorado. Prof. F. L. Harvey found this species very destructive in Maine and published a valuable account of it in Bulletin 35 of the Maine Exp. Sta., 1897. The dark species appears to have been recorded only from Washington.

DESCRIPTIONS AND LIFE HISTORIES.

The yellow currant fly in the adult stage is about the size of a common house fly or a little smaller, pale yellow or orange, with greenish eyes and dark patches or stripes on the wings. In Washington they were observed about the bushes from May 10 to June 30. The female lays about two hundred eggs according to Prof. Harvey and occupies about a month in the process, laying usually one egg on a berry. The egg soon hatches into a white footless maggot which bores to the center of the berry and remains until fully grown or about three weeks, feeding chiefly on the seeds which it hollows out, often disappearing within a seed. When fully grown it bores to the surface and leaves the fruit either before it drops to the ground or after. It burrows into the ground and forms a pupa in which state it remains till the following season.

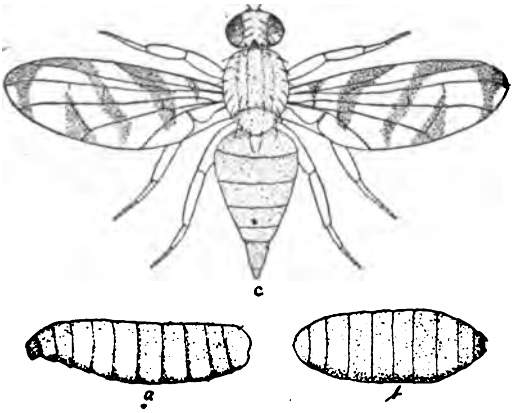


Fig. 24.—The yellow currant fly: a, larva; h, pupa; c, adult; all much enlarged. (Doane, Bulletin 36, Washington Exp. Sta.)

The adult dark currant fly according to Prof. Piper and Mr. Doane is only about half as large as the common house fly. The body is shining black, with two narrow yellow lines on the sides in front of the wings and a rather conspicuous yellow spot in the middle of the back. The head is pale yellow; the eyes greenish irridescent; the legs are also pale yellow, the second joint from the body much darker, sometimes almost black. The wings are prettily marked with four cross bands as shown in figure 25,a.

In Washington the flies are on the wing from June 15 to July 15. Aside from the time for appearing and disappearing in the spring being later, the life history, so far as known, does not differ essentially from that of the yellow species.

REMEDIES.

The eggs of these insects are deposited under the skin and spraying would do no good. Frequent gathering and destroying the fallen berries will greatly reduce the number which will appear the following season to lay eggs for the new brood. This method will not reach all since some of the maggots leave the currants before they drop. The maggots burrow into the ground for a short distance, probably not over an inch and if the surface earth is removed and either buried or put in a road or other exposed place, the larvae will be killed.

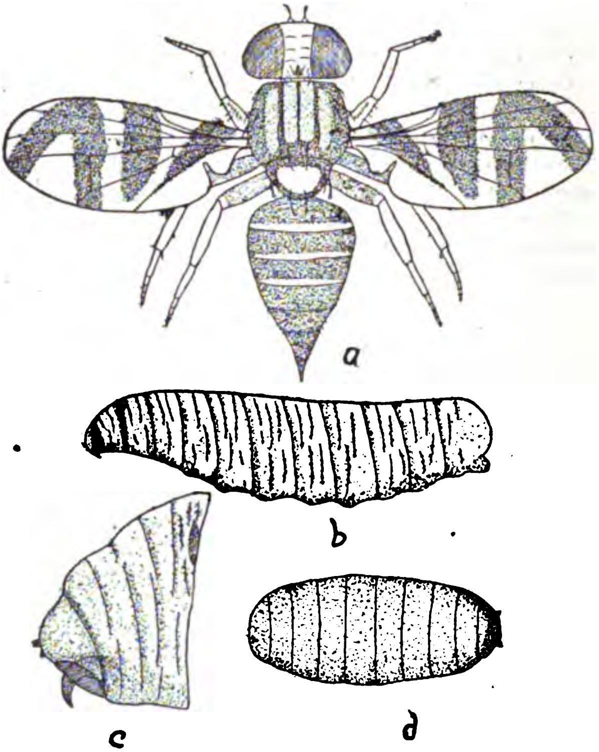


Fig. 25.—The dark currant fly: a. adult; b. larva; c. head and first segment of larva: d. pupa: all much enlarged. (Doane, Bulletin 36, Washington Exp. Sta.)

The Washington bulletin mentioned above, recommends as the surest method of ridding the bushes of this pest, gathering and destroying the entire yield of currants before the nisects have time to leave. This is no doubt advisable provided there are no infested neighboring bushes from which reinfestation may occur the following spring.

The Pear-leaf Blister-mite.

(Phytoptus pyri Scheuten.)

The pear-leaf blister-mite though not an insect, strictly speaking, is given a place in this bulletin because of its importance as a fruit pest and because it has been found causing injury to pear trees in Montana.

ORIGINAL HOME AND PRESENT DISTRIBUTION.

There can be little doubt that Europe is the original home of the mite and that it has been distributed in nursery stock to the other countries in which it now occurs. It has been reported also from South Africa, Australia and Canada, and is quite generally distributed in the United States. It is perhaps more prevalent on the Pacific slope than elsewhere in this country.

FOOD PLANT.

This pest has never been reported to attack any kind of tree other than the pear, so far as is knwon to me, and it is probable that it confines its attack to this fruit tree.

NATURE OF ITS ATTACK.

As the leaf buds unfold in the spring, there may be seen red spots or blotches an eighth of an inch or more in diameter scattered more or less numerously over the surface of the young and tender leaves. The young galls are more distinctly seen on the upper side of the leaves but later on the spots gradually turn brown owing to the death of the tissues composing the blisters or galls, after which the galls are more conspicuous on the under side of the leaves. The blisters may be small and distinctly separated from each other or fused together forming quite extensive patches. In each blister, on the under side of the leaf, may be seen one or more minute holes leading into the cavity of the blister and usually visible only under a lense or microscope. In the cavity within the substance of the leaf the

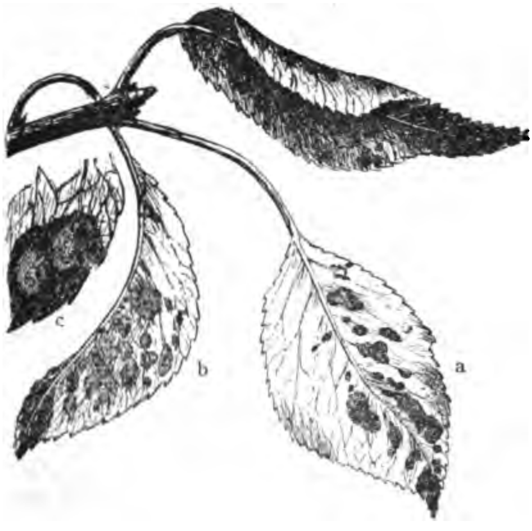


Figure 26.

very minute and delicate mites live, feeding on the juices of the plant. A single gall often accomodates a great many individuals. Within the shelter of these galls the mites are very effectively protected from wind and rain which might easily sweep them away were they exposed on the surface. The tender tissues on the inside of the galls also furnish better facilities for the mites to acquire nourishment than would the thicker layers of cells on the surface. The freshly formed galls are thick and succulent but as they die and turn brown they shrivel and dry.

THE MITE.

The effects of the presence of the mites are much more apparent than the mites themselves which are so small as to be hardly visible to the unaided eye. A high power microscope is necessary in order to study their structure. The body is elongated and is made up of a large number of rings. There are four legs all of which are placed at the anterior end of the body and though small they enable the mite to move very rapidly. The head is made up chiefly of a conical snout within which are two lance like jaws. About one hundred and fifty mites placed end to end would be required to cover a linear inch and they are about four times as long as wide

LIFE HISTORY.

The eggs are laid within the galls which the mites form. The young mite hatching from egg leaves the gall through the hole made by the parent in entering and after finding an uninjured spot on the leaf bores into the tissues and starts a new gall. The mites remain in the galls until the end of the season, when they migrate to the buds at the ends of the twigs and seek shelter for the winter beneath the scales of the bud. Some of the mits rmain on the leaves too long and are borne to the ground when the leaves fall.

POWER OF INJURY.

The blister-mite by its injury to the leaves causes them to die and drop off long before the natural time.

The mite is dependent on outside agencies—traffic in nursery stock for example—for means of distant dissemination as it cannot fly and can crawl only a short distance. It is often quite severe on individual trees but it spreads to neighboring trees but slowly.

REMEDIES.

Protected as the mites are within the galls no spraying mixtures will reach them. The only vulnerable point in their life cycle is when they are in the leaf buds after the leaves have fallen. Prof. M. V. Slingerland has found that the mite "can be nearlly exterminated in a badly infested orchard by a single thorough spraying of the trees in winter with kerosene emulsion diluted with from five to seven parts of water."

On young trees in the beginning of the attack, no better remedy can be found than to pick off and destroy all the affected leaves as fast as they appear.

The Oregon Board of Horticulture recommends and has found efficient an application of lime, sulphur and salt solution. Various others have also found this last remedy effective.

Insecticides.

For the purposes of this paper we may divide insecticides into two general classes: Those that kill by being eaten by the insect with its food and those that kill by simply coming in contact with the body of the insect. Those of the first group are known as stomach poisons and are used chiefly against insects that eat the foliage or other surface parts of plants, as the Colorado potato beetle, tent caterpillars, and larvae of the codling moth. Insecticides of the second class are employed against insects that extract the juices of plants by means of a sucking beak which is inserted into the tissues. A poison placed on the surface of the plant does not injure the insect since the food is taken from the unaffected sap beneath. Examples are the different species of plant-lice and scale insects. Of course there are many insects which cannot be reached with either of the above classes of insecticides; chief among these are internal feeders or borers, subterranean insects and household pests.

By far the most important stomach poisons are those which contain arsenic as the killing agent. An arsenical insecticide to be of greatest service must not be readily soluble in water, for its injury to the foliage other things being equal, is directly proportionate to its solubility. It should remain suspended in water in order that it may be evenly distributed on the foliage. It should contain a large percentage of arsenic so as to kill the insects quickly. It is desirable to have it remain on the foliage through rain storms and so prevent the necessity of frequent spraying. All of these things as well as the cost should be considered in selecting an insecticide. Ordinary white arsenic of commerce would be a very valuable insecticide were it not for the fact that it is so soluble in water, and hence very injurious to the foliage. For this reason it is compounded with other substances thereby making it insoluble.

PARIS GREEN.

Paris green is the oldest and best known arsenical insecticide. Its first general use was in the western states against the Colorado potato beetle somewhere between the years 1860 and 1870. It soon became the popular remedy for many other insects and is now very widely known and used. It contains a high percentage of arsenic and is only slightly soluble in water. Being made up of granules it settles in water very quickly, and should be constantly agitated in order that it may be evenly distributed over the foliage.

A great deal has been said in recent years about adulteration of this insecticide and beyond doubt much injustice has been done to agriculturists through the sale of inferior and adulterated goods. The harm done in selling adulterated Paris green is not so much in the fact that more arsenic is paid for than is obtained, as that the agriculturist goes to the labor and expense of applying what he supposes to be a fatal dose of arsenic when, because of inferior quality in the poison the application may be wholly or partly without effect. Several states have passed laws requiring that Paris green offered for sale contain at least 50 per cent of arsenic. The chemist of this Station, Dr. F. W. Traphagen, is examining insecticides on sale in this state and has so far discovered no case of adulteration. The complete results of his investigation will be published in bulletin form later on.

In spraying with this substance a hot day should be avoided if possible, especially if it is desired to apply nearly all the foliage will stand without injury. The water soon becomes warm on the foliage and when warmed dissolves the Paris green more readily.

LONDON PURPLE.

London purple came into the market soon after Paris green and has been a poor rival ever since. It possesses the advantage of being considerably cheaper than Paris green but is variable in quantity of arsenic and never contains as much as does Paris green. More of the arsenic is in a soluble form so that it is much more liabel to injure foliage. The addition of an equal quantity of freshly slacked lime is often recommended to prevent this injury. This insecticide has been used largely in the destruction of the Colorado potato beetle since the foliage of potatoes is not easily injured.

ARSENATE OF LEAD.

The committee of the Massachusetts Board of Agriculture in charge of the work of exterminating the Gypsy Moth, in the course of its work soon found that Paris green was not sufficiently deadly against the larvae, and set about discovering a more effective poison. It has been rewarded in the discovery of the insecticidal properties of arsenate of lead. This substance may be applied in any strength without injury to the foliage and when properly applied remains on the foliage through rain storms. Its white color makes it easily detected on the foliage.

The substance is made by the union of acetate of lead and arsenate of soda, both being in solution. Up to last season the agriculturist was obliged to make the substance himself which seriously interfered with its general use. Wm. H. Swift, Chemist, of Boston, placed the insecticide on the market in paste form in 1899 and his preparation was quite generally used in the eastern states. It is now offered for sale also by the Bowker Chemical Company, Boston, Mass. The substance deserves a thorough and general trial by the people of Montana. It can be obtained a little cheaper than Paris green.

ARSENITE OF LIME.

The desire for a reliable and a cheaper arsenical insecticide has led to the employment of a product resulting from the union of freshly slaked lime and commercial white arsenic. The proportions are:

Commercial white arsenic	1 pound
Unslaked lime	2 pounds.
Water	2 gallons.

Boil together for twenty minutes to half an hour. As soon as the arsenic is dissolved it is precipitated by the lime as insoluble arsenite of lime. There is danger however that not all the arsenic will be precipitated out as it is difficult to tell when all has been dissolved. For this reason the following formula is considered much more reliable:

White arsenic	2 pounds
Sal soda	4 pounds
Water	2 gallons.

Boil for about fifteen minutes or until all is dissolved, leaving a clear liquid. Add water enough to replace what has boiled away to prevent chrystalization of the arsenite of soda. A large quantity may be prepared at one time and kept as a stock solution to be used when desired. It should be covered to prevent evaporation and plainly labeled for it is a deadly poison. One pint of this stock is approximately equivalent to four ounces of Paris green. It should be used only in a solution in which lime is present for, as is seen above, it is soluble in water. With lime it forms arsenite of lime which is the resulting product of the previous formula. It may also be used in connection with Bordeaux mixture in which case Bordeaux mixture is used as a diluent in place of water.

Counting the cost of the preparation of arsenite of lime it is not probable it will be found cheaper unless large quantities are to be used. In using this substance in preference to Paris green, however, one avoids the danger of purchasing adulterated goods.

HELLEBORE.

Hellebore has a narrow range of usefullness and is effective chiefly against saw-fly larvae as the currant worm and pear-tree slug. It kills either by coming in contact or by being eaten. It is usually dusted on the foliage either pure or mixed with twice its amount of land plaster or cheap flour. The foliage should be moist when it is applied in a dry form, otherwise it will not remain on the leaves.

In Montana, where the foliage is almost perpetually dry, it would be better to apply it as a spray at the rate of one ounce to 2-4 quarts of water. Steep in one pint of boiling water and add cold water gradually.

CONTACT INSECTICIDES.

Contact insecticides kill either by caustic effects or by interfering with breathing. Different soaps, preparations of kerosene, substances which form a coating over the body and thus prevent breathing, belong to this class.

KEROSENE EMULSION.

Pure keresone is fatal to almost all insects. It is extremely penetrating and enters the breathing pores of the insects and interfering with their breathing causes their death. Pure kerosene, however, is more or less injurious to plant life and for this reason has to be diluted in some way. Since it will not mix with water it is necessary to form an emulsion and soap is usually used for this purpose.

A good formula is:

Ordinary bar-soap....	½ pound
Soft water....	1 gallon
Kerosene....	2 gallons.

The water is placed over a stove to heat and the soap shaved into it. When the soap is dissolved and the water has reached the boiling point the solution is poured into the kerosene and vigorously churned for four or five minutes with a force pump the nozzle of which is directed back into the vessel. The mixture takes on a milky appearance and on cooling becomes jelly like. This is the stock emulsion and if properly prepared will keep for a considerable length of time, but should be diluted when used. Failure of the soap to dissolve readily often hinders in the preparation of the insecticide. Ordinary soap powders will dissolve almost immediately and Mr. A. H. Kirkland found that they could be used as a substitute for the soap provided the emulsion is to be used at once. This insecticide should be very popular in Montana but it is surprising to see how many fruit growers prefer whale-oil soap solution. In some parts of the state fruit growers are going back to kerosene emulsion believing it to be more reliable and less likey to injure the foliage if thoroughly prepared.

WHALE-OIL SOAP.

Whale-oil soap, more correctly known as fish-oil soap, is of great value as an insecticide against certain classes of insects particularly scale insects. Some species of plant lice which fail to succumb to an application of very strong kerosene emulsion are readily killed with a solution of whale-oil soap. An example is the louse so commonly attacking spruce trees in Montana causing cone-like galls on the twigs.

Ordinary foliage will not safely stand a stronger solution than one pound in 4 gallons of water. Most plant lice are readily killed by 1 pound in 6 gallons of water. If a good whale-oil soap cannot be obtanied a substitute may be made by the following formula:

Concentrated lye	3½ pounds.
Water	8 gallons.
Fish-oil	1 gallon.

Dissolve the lye in boiling water and add the oil to the solution still boiling. Continue to boil for two and a half hours and then allow it to cool The fish-oil can be obtained in eastern markets and beyond doubt it would be cheaper for the fruit grower to make his own soap provided he intends to use a considerable quantity.

RESIN WASH.

This insecticide is a favorite in the Pacific states particularly California where it is used chiefly against scale isects infesting citrus trees. Others have found it very useful as a remedy for various plant lice.

The wash may be made as folows:

Resin	20 pounds.
Crude caustic soda (78 per cent)	5 pounds.
Fish-oil	2½ pints.
Water to make	100 gallons.

Place the resin. soda and oil in a kettle with sufficient water to cover them three or four inches deep; boil about two hours making occasional additions of water. The compound will take on the appearance of strong black coffee. Add sufficient hot water to make one third the final bulk or the same amount of cold water added gradually over the stove. This is the stock mixture and must be diluted to 100 gallons when desired for use.

BORDEAUX MIXTURE.

While this substance is more a fungicide than an insecticide it is given a place here because of its great usefulness and because it is often used in place of water in the application of arsenical insecticides. Where it is desired to spray an orchard with Bordeaux mixture and an arsenical insecticide it is of course clear gain if both can be applied in one spraying. This fungicide may be prepared as follows:

Sulphate of copper	6 pounds.
Quick lime	4 pounds.
Water	22 pounds.

In one vessel dissolve the copper sulphate in 1 gallon of hot water and in another vessel slake the lime with 1 gallon of water. Slowly add the lime to the copper solution stirring constantly; then strain through a sieve of gunny sack.

This is the standard full strength Bordeaux mixture and may be diluted according to the purpose to which it is put.

PATENT INSECTICIDES

While there may be some patent insecticides which deserve commendation and use the vast majority of them are to be passed by. Such insecticides are usually gotten up simply to sell. They are often said by their advocates to be harmless to man, but when this is true they are usually harmless to insects also. Most of them if not absolute frauds are preparations in which our old and well known insecticides are the active agents. In other cases while they would destroy insects they are also very injurious to plants. It is much better to use the old standard insecticides and avoid supporting an unnecessary business.

PROPER TIME TO SPRAY.

For any given insect the proper time to spray may vary in different years. We cannot set a date on which to spray for codling moth or other insects each year. It is well known to all that vegetation is much more forward one season than in another and it should be realized that insect life depends upon the same conditions to awaken it to activity as does plant life. It cannot be too strongly urged upon the fruit grower to observe the habits of insects which trouble him and so enable himself to guard against their ravages.

INJURY TO FOLIAGE BY INSECTICIDES.

It is well known to agriculturists that many insecticides if used in too great strength will injure the foliage. When injured in this way the leaves lose their natural color and drop to the ground. If not too late in the season a second growth is put out which weakens the tree and often prevents fruiting the next year. This change of color and dropping of leaves may not be apparent for several days after the application of the insecticide, particularly if no wet weather occurs.

Stone fruits as a class are much more liable to injury than pomaceous fruits.

WHEN IS A TREE THOROUGHLY SPRAYED?

Success in spraying depends very largely upon the thoroughness with which it is done. One cannot expect good results from haphazard attempts at spraying. It is not necessary that a large amount of the insecticide be applied; the aim should always be to use just as little as possible and yet cover all parts of the tree. It is not the correct way to attempt to throw a heavy stream from the ground and hit all parts. A nozzle producing a fine mist-like spray should be elevated and applied to one part of the tree until the foilage just begins to drip. It should be remembered that when contact insecticides are used a portion of the spray must touch the body of each insect. It does no harm to an insect to walk over a leaf which has been previously sprayed with a contact insecticide.

PROMPT MEASURES NECESSARY.

Montana fruit growers cannot too highly value their comparative freedom from insect pests. They also have a great advantage in the fact that the accumulated experince of other fruit growing states is theirs. When ever it is known that an insect pest has made its appearance in an orchard or vicinity prompt and vigorous means should be adopted against it. Our advantage is forever lost if we wait till we are overrun before we begin action.

Insecticide Apparatus.

It is purposed here to give as briefly as possible the principles underlying the use of insecticide machinery and describe the leading types, the aim being to aid the agriculturist in selecting an outfit.

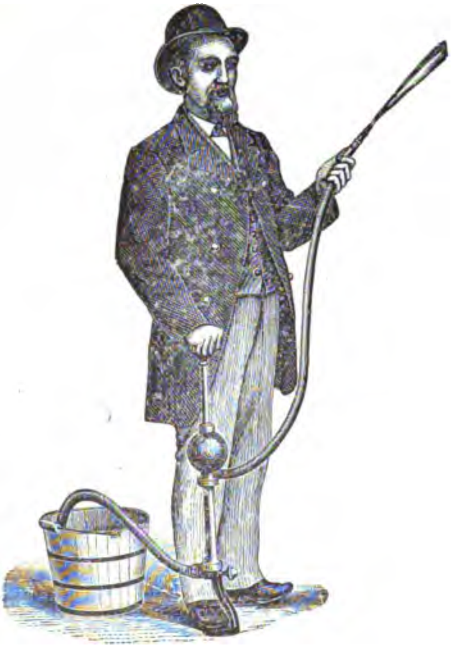


Figure 1.

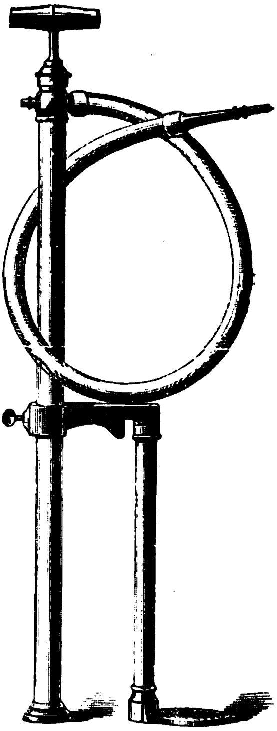


Figure 2.

We would state at the outset that a fruit grower desiring an outfit should write to the various pump manufacturers and obtain their catalogues. These will greatly aid in making a selection. It is not intended here to recommend one make of pump or other apparatus over another. All have their good points. It is desired rather to give the purchaser such informa-

tion as will help him to select for himself. The following is a list of some of the best known dealers:—

The Field Force Pump Co., Lockport, N. Y.
The Nixon Nozzle and Machine Co., Dayton, Ohio.
William Stahl, Quincy, Ill.
The Gould's Manufacturing Co., Seneca Falls, N. Y.
W. & B. Douglas, Middletown, Conn.
Rumsey & Co., Seneca Fals, N. Y.
Deming Co., Salem, Ohio.
J. J. McGowan, Ithaca, N. Y.
F. E. Myers & Bro., Ashland, Ohio.
Wm. Boekel & Co., 518 Vine Street, Philadelphia, Pa.
The Bean Spray Pump Co., Los Gatos, Cal.
The Bean-Chamberlain Manufacturing Co., udson, Mich.
Morrill & Morley, Benton Harbor, Mich.

For use on a few trees about the home a good spraying outfit is a hand pump in a bucket with sufficient hose to lead to the nozzle when elevated into the tree. The hose may be detachable and the pump made use of for other purposes also. The pump illustrated in figure 1, manufactured by Rumsey and Company, and the one in Fig. 2, made by W. & B. Douglas are examples of this kind. The Deming Company has furnished the Station

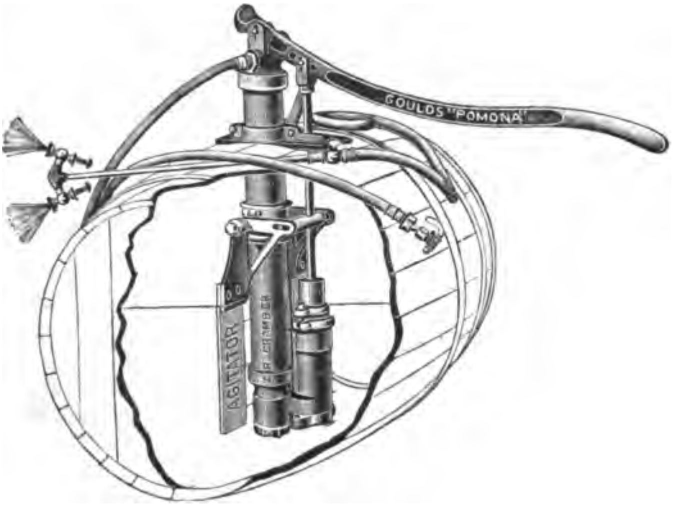


Figure 3.

with a similiar pump, known as the "Success" which has given entire satisfaction.

A knapsack sprayer is almost indispensable to a grower of small fruits such as raspberries and strawberries. Fig. 6, illustrates a knapsack sprayer for sale by W. & B. Douglas. The one shown in Fig. 7, made by the Deming Co., is so constructed that it can be used either as a knapsack or as a bucket sprayer.

When spraying is done on an extensive scale a different outfit is required. A pump should be procured which will supply at least two lines of hose. A great variety of such pumps is offered for sale. The working parts should be as simple as possible, and it is desirable that it be easily taken apart for repairing.

The working parts should be of a non-corrosive metal. The accompanying illustration, Fig. 3, shows a pump of this type manufactured by the Gould's Co. Another style of pump in favor in the Pacific states is that illustrated in Figs. 4 and 5, the former manufactured by the Bean Spray Pump Co. and the latter by F. E. Myers & Bro. These pumps are attached to the platform beside the tank and are fed by a pipe leading to the spraying mixture.

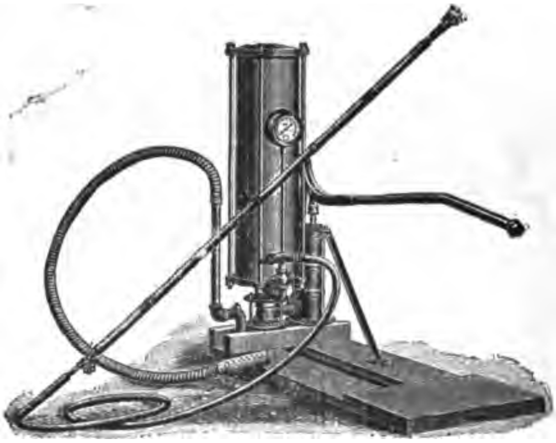


Figure 4.

When applying most spraying mixtures it is necessary that some kind of an agitator be used. This may be a paddle which is worked with each stroke of the pump (see Fig. 3.) or a portion of the stream leading away from the pump may be directed back into the vesel.

It is important that there be some device for indicating the pressure

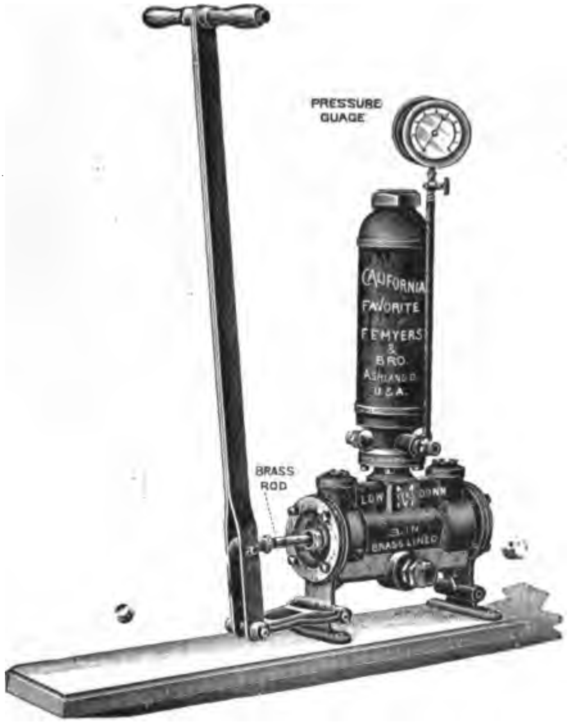


Figure 5.

of the liquid in the pump and hose. The man working the pump can then tell whether or not he is maintaining sufficient pressure.

In order that the hose may be as light as possible it should be only one-half or three-fourths of an inch in diameter. Rubber is more durable than canvas hose. A good line of hose couplings, hose clamps, extension pole holders, ect., is carried by the Deming Co.

The extension pole for elevating the nozzle should be as light as possible. In place of a pole a piece of small gas pipe may be used, the nozzle being attached at one end and the hose at the other. A nozzle should be se-

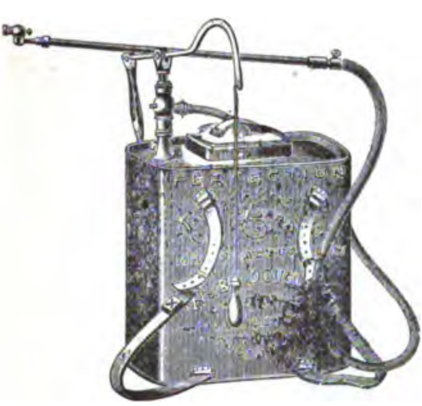


Figure 6.

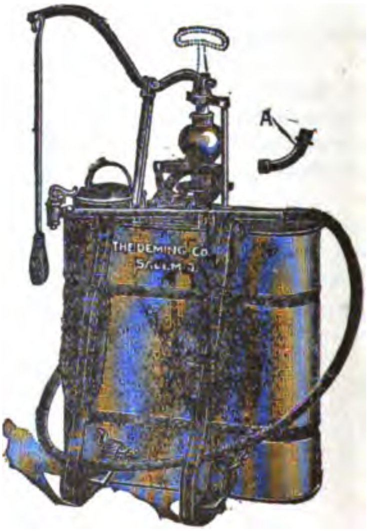

A
THE DEMING CO.
SALEM O.

Figure 7.

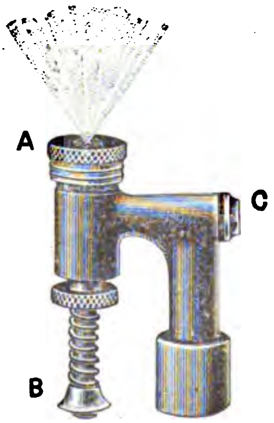


Figure 8.

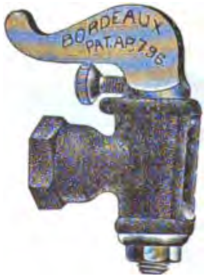


Figure 9.

lected which will produce the proper kind of spray and when clogged can be cleared without waste of time.

Fig. 9, illustrates a very useful nozzle known as the "Bordeaux" and manufactured by the Deming Co. The spray is produced by a solid stream being thrown against a metallic lip. The nozzle shown in Fig 8, made by the Field Force Pump Co., the one given in Fig. 10, made by F. E. Myers and Bro., and the one shown in Fig. 11, are all made on the principle of the "Vermorel" and are furnished with a degorger to clear out the opening when it gets clogged. Fig. 12, shows a double nozzle for sale by Morrill and Morley. Triple and quadruple nozzles may also be obtained. These multiple nozzles while not altering the character of spray increase its volume, and so make more rapid spraying possible.

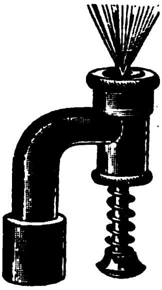


Figure 10.

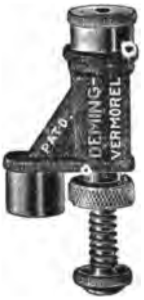


Figure 11.

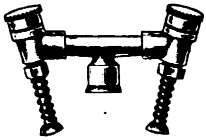


Figure 12.

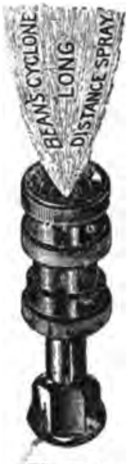


Figure 13.

Fig. 13, illustrates a nozzle made by the Bean Spray Pump Co., which can be cleared by simply pushing the end against the tree.

In orchard spraying it is often a great advantage to have a platform elevated about five feet above the wagon body. A man standing on this platform can reach with a pole into the upper branches of the tree and can spray the lower limbs also.

R. A. COOLEY.

630.679
M19eb

BULLETIN NO. 24.

Montana
Agricultural
Experiment Station

......OF......

THE MONTANA COLLEGE OF AGRICULTURE.

Sixth Annual Report

OF THE

Treasurer, Director, Horticulturist, Chemist. Asst. Agriculturist, Entomologist and Botanist.

BOZEMAN, MONTANA, JULY, 1899.

ROCKY MOUNTAIN HUSBANDMAN
White Sulphur Springs,
MONTANA.

Montana Agricultural
EXPERIMENT STATION.

LETTER OF TRANSMITTAL.

To His Excellency, Robert B. Smith, Governor of Montana:

Bozeman, Montana, February 1, 1900.

DEAR SIR—I have the honor to transmit to you herewith the Sixth Annual Report of the Montana Agricultural Experiment Station.

Respectfully,
S. M. EMERY, Director.

EXECUTIVE BOARD.

LESTER S. WILLSON, President	Bozeman.
PETER KOCH, Secretary and Treasurer	Bozeman.
GEORGE KINKEL, JR., Vice-President	Manhattan
WALTER S. HARTMAN	Bozeman
JNO. M. ROBINSON	Bozeman

EXPERIMENT STATION STAFF.

S. M. EMERY,	Director and Horticulturist.
F. W. TRAPHAGEN, Ph. D., F. C. S	Chemist.
ROBT. S. SHAW, M. S., B. S	Assistant Agriculturist.
J. W. BLANKINSHIP, Ph. D	Botanist.
E. V. WILCOX, Ph. D	Biologist
SAMUEL FORTIER, Ma. E	Irrigation Engineer.
R. A. COOLEY, M. S	Entomologist.

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

MONTANA EXPERIMENT STATION,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana (so long as the supply lasts) who sends his name and P. O. address to the Station for that purpose.

Report of Treasurer of Board.

The Experiment Station of the Agricultural College of the State of Montana in Account with the United States Appropriation, 1898-99:

Dr.

To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1899, as per Act of Congress, approved March 2, 1887	$15,000 00
To receipts from sale of farm produce	1,242 61
To receipts from State appropriation	787 50
Total receipts	$17,030 11

Cr.

By Salaries	$ 8.293 84
Labor	3,309 25
Publications	465 43
Postage and Stationery	131 89
Freight and Express	247 34
Heat, Light and Water	585 50
Chemical Supplies	239 68
Seeds, Plants and Sundry Supplies	373 69
Fertilizers	15 00
Feeding Stuffs	21 85
Library	108 19
Tools, Implements and Machinery	151 70
Furniture and Fixtures	35 83
Scientific Apparatus	292 56
Live Stock	224 50
Traveling Expenses	540 75
Contingent Expenses	50 50
Building and Repairs	1,423 79
By balance	$ 568 82
	$17,030 11
To unexpended balance	$ 568 82

We, the undersigned, duly appointed Auditors of the cerporation, do hereby certify that we have examined the books and accounts of the Montana Experiment Station for the fiscal year ending June 30, 1899; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000,000, and the receipts from sale of farm produce $1,242.61, and the receipts from State appropriation $787.50, and the corresponding disbursements $16.461.29, for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving a balance of $568 82.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

Attest:
PETER KOCH,
Custodian.

Signed:
L. S. WILSON,
W. L. HARTMAN,
PETER KOCH.
} Auditors.

MONTANA EXPERIMENT STATION.

Bulletin No. 24. *July, 1899.*

Annual Report of the Director for the Fiscal Year Ending June 30, 1899.

STATION STAFF.

E. V. Wilcox resigned April 1st, 1899, having been elected Assistant Entomologist to the Department of Agriculture, Washington, D. C.

J. W. Blankinship, Ph. D., of Harvard, Mass., was elected Botanist July 1st, 1898.

Samuel Fortier, Ma. E., of Ogden, Utah, was elected as Irrigation Engineer May 15, 1899.

Robert A. Cooley, B. S., of Amherst, Mass., was elected as Entomologist June 15, 1899.

EXPERIMENT STATION IMPROVEMENTS.

A greenhouse 20x40 feet was constructed immediately west and adjoining the greenhouse erected in 1897; the west brick wall of greenhouse No. 1 forms the east wall to greenhouse No. 2, and the north, south and west walls of greenhouse No. 2 are made of wood as follows: Round red cedar posts were set two feet apart on the line of the outer walls and two feet in the ground on the respective lines of the house first having been flattened on either side, to these were nailed rough common lumber on outside line. On this was tacked tarred paper and a second course of rough common lumber. On this sheeting a second course of tarred paper and upon this thickness of rough lumber and tarred paper, cedar shingles were laid five inches to the weather. Where the soil would encounter the walls of the building rough boards were nailed on the outside and banked with earth. The sash bars, ventilating apparatus, glass and doors are substantially the same as in greenhouse No. 1. It is heated by steam carried by a 1¼ inch black pipe; twelve runs under the benches supply all the heat required. Cost of building $314.14.

The variation in walls of the two buildings was made from brick to wood to test the relative value of the materials in such position. Greenhouses are peculiar in that they should be saturated with damp air. This permeates the walls, and it has been found that the action of frost on brick walls, subject to such damp hot air internally, is much greater than a brick wall exposed to a drier atmosphere. No doubt fungi and bacteria work more vigorously, too, under such conditions on wooden walls, but spite of this fact the life of wooden walls thus constructed is supposed to be greater than that of brick. Although the brick walls carry hollow air spaces the temperature in the two buildings was substantially the same, though the extremes of temperature were greater than for six years.

FARM IMPROVEMENTS.

A machine shed 24x40 was built, costing $125.

A hay barn 24x40 x20 feet high was built of peeled pine logs. The roof was built of 2x4 rafters, rough board sheeting and Washington cedar shingles. The frame is made of round pine and fir timbers from the adjacent mountains, and was planned so that the lower nine feet of the ground story can be changed into a cow stable at nominal expense. Contract price of this $126, outside of supplying round timbers. This and other storage capacity supplies a place for 125 tons of hay, an amount that should be produced annually from the farm under the present system of sowing clover in all barley fields, with or subsequent to seeding to barley.

Each successive season emphasizes the fact that Montana is essentially a clover state. All of these legumes, ranging from the white clover, (the ideal plant for lawns and bee pastures and the dwarf member of the group), up to the field pea which for length of straw, (frequently reaching twelve feet) and size of fruit, may very properly be classed as the giant of the family; succeed admirably and tell us that so far as an ideal crop for animal flesh production and as a renovator of exhausted nitrogen from soil by grain production, that Montana need ask no odds of any of the great corn states of the Union.

Given bright well cured clover hay and Canada field peas in rank abundance and upon every count of pork, beef, mutton, poultry and dairy products, we can not be excelled for the crude material from which to manufacture the very choicest of these products.

Our advice was requested this season by one of the best and oldest farmers, owning 480 acres of the cream of Gallatin County lands, upon the subject of clover.

Said he, "I have been summer-fallowing my farm for twenty-five years and it is beginning to cease to respond to the fallow system. I can't supply barn yard manure to so large an area and I am confident that I must begin the cultivation of clover. How and where should I begin?" Our reply was that it was a matter of taste, whether 80 or 160 acres should be devoted each year to clover. It should be begun and followed up consecutively until the entire farm had been clovered. Many complain that red clover and alfalfa, the two favorite legumes, kill out after three or four years, and the meadows thus sown carry a poor stand and become weedy. Many contend that red clover is an annual, and unless permitted to reseed will naturally be short lived. No where do the legumes seed as in Montana, and if the first crop be permitted to seed each third year, there need be no difficulty in always having a strong lush growth of clover, but we doubt if for many years we can afford to let clover lands stand as seeded fields, if situated favorably to grain market or where grain can be fed. It is doubted if in any other region outside of the Montana environment, where irrigation is feasible it is possible to harvest red clover inside of 100 days from seeding and to secure a weighed ton of well cured hay. We have never failed to do this when seeded alone and the lands thus occupied to clover have produced a ton of cured clover per acre, worth $6 per ton, the finest food for live stock, and are really in better heart for a good grain crop than if clover stubble of four years standing should be grain sown.

In the latter case the clover root development has been so great and the nitrogen deposit so excessive that the result is abnormally heavy grain, too much so to stand up and ripen well, so that it can well be afforded to plow under the meadows of one or two years standing, the results being more satisfactory in the medium development of the grain yields.

Among many other interested visitors, was the Representative of the extensive Nitrate Mines of Strassfurt, Germany, Dr. Jno. A. Meyers of New York. He had frequently expressed the desire to have this Station experiment with potash on grain crops. On seeing the situation, viewing the crops and the growth of straw, his comment was, "It will be 25 years before you need to use potash on these soils." We are long on the expensive requisites, potash and phosphoric acid and if the grain farmers of Montana will only take heed to weave in a substantial proportion of legumes into their crop fabric, they need not worry for many years over depleted yields and exhausted soil fertility.

BULLETINS.

The following bulletins have been issued during the current year :

Bulletin No. 21, 13 pages, "Sheep Feeding," by Robert S. Shaw, B. S. A.

Bulletin No. 22, 42 pages, a series of monographs upon "The Resistance of Strawberries to Frost;" "Potato Scab;" "Treatment of Seed Oats for Smut;" "Losses Caused by the Grain Aphis;" "Roup of Chickens;" "The Internal Chicken Mite;" "Lupines as Plants Poisonous to Stock;" "Cattle Poisoning by the Tall Larkspur;" "Poisoning of Stock by the Water Hemlock;' "Ergotism in Horses;" "The Poisoning of Cattle by Smutty Oat Hay;" "List of Plants of Known or Suspected Properties Which Occur Within the State;" "Some Native Forage Plants of the State," by E. V. Wilcox, Ph. D.

Dr. Wilcox severed his connection with the Station April 1, 1899, but this work was performed by him while a member of the Statio Staff. He resigned as Biologist of the Montana Experiment Statio to accept the position of Assistant Entomologist to the Department o Agriculture, Washington, D. C.

Bulletin No. 23, 64 pages, "The Insect Pests of Fruit in Montana Insecticides and Spray Appratus," illustrated, by R. A. Cooley, B. S. Entomologist.

Bulletin No. 24, 36 pages, Sixth Annual Report of the Montan Experiment Station.

By authority of the Executive Board Bulletins Nos. 22, 23 and were issued in editions of 6500 copies. The demand for Bulletins constantly growing, many calls coming from other states in the Unio

We feel to supply all the requests as long as there are available copies, and we reiterate the importance of preserving all numbers received by those on the regular mail list.

There is not a state in the Union which can supply a complete file of its publications, outside of its own preserved files, and it is usually the bulletin that is out of print for which the strongest demand exists.

PRESS LIST.

We thank the friends who publish papers and send to the Station in exchange for its publications. No doubt they are actuated by the double purpose of doing good and putting themselves in the way of valuable information to be found in the Experiment Statioh Bulletins. We renew our offer on the part of the Staff of the Station to supply gratuitous contributions on subjects of scientific agriculture of interest to the press. The press of the State has been very kind to the members of the Montana Experiment Station Staff. Harsh criticisms so often noted in the press of other states toward Station workers has been with us entirely lacking and the heartiest co-operation has always been extended in our efforts in behalf of Montana agriculture.

The following list has come regularly to the Station :

Democrat-Messenger, Missoula.
Independent, Helena.
Inter Mountain, Butte.
Missoulian, Missoula.
Northwest Agriculturist, Minneapolis.
Agricultural Student, Columbus, O.
Dorset Courier, Washington, Pa.
Dixie Miller Nashville, Tenn.
Elgin Dairy Report, Elgin, Ill.
Field and Farm, Denver, Col.
Farmers' Voice, Chicago, Ill.
Farm, Stock and Home, Minneapolis.
Farmers' Guide, Huntington, Ind.
Farmers' Call, Quincy, Ill.
Florists' Review, Chicago, Ill.
Garden and Field, Adelaide, New South Wales.
Green's Fruit Grower, Rochester, N. Y.
How to Grow Flowers, Springfield. O.
Hoard's Dairyman, Fort Atkinson, Wis.
Forester, Philadelphia, Pa.
American Florist, Chicago, Ill.
Farm Journal, Philadelphia, Pa.
Farm Students' Review, St. Anthony's Park, Minn.
Holstein Register, Brattleboro, Vt.
Home and Garden, St. Paul, Minn.
Home and Farm, Louisville, Ky.
Horticultural Visitor, Kinmundy, Ill.
Irrigation Age, Chicago, Ill.
Jersey Bulletin, Indianapolis, Ind.
Montana Fruit Grower, Missoula, Mont.
Northwest Farmer, St. Paul, Minn.
Nebraska Farmer, Omaha, Neb.
Rocky Mountain Husbandman, White Sulphur Springs, Mont.
National Stockman and Farmer, Pittsburg, Pa.
North American Horticulturist, Monroe, Mich.
Wallaces' Farmer, Des Moines, Iowa.
Wisconsin Agriculturist, Racine, Wis,
Wool Record, New York.
Western Fruit Grower, St. Joseph, Mo.
W. Va. Farm Review, Charleston, W. Va,
Farm and Poultry, Boston, Mass.
Inter Mountain Poultryman, Tiffin, O.
Oregan Poultry Journal, Salem, Ore.
American Poultry Journal, Chicago, Ill.
Poultry Monthly, Albany, New York.
Poultry Culture, Kansas City, Mo.

Pacific Poultryman, Tacoma, Wash.
Poultry Herald, St. Paul, Minn.
The Feather, Washington, D. C.
Weekly Sun, Baltimore, Md..
Republican' Lake City, Minn.
Northwest Magazine, St. Paul, Minn.
The World, Vancouver, B. C.
Avant Courier, Bozeman.
Belt Valley Times, Belt.
Times, Billings.
Pioneer, Big Timber.
Chronicle, Bozeman.
Opinion, Chinook.
College Exponent, Bozeman, Mont.
Examiner, Dillon.
Tribune, Dillon.
Inter Lake, Kalispell.
Independent, Glendive.
Post, Livingston.
Enterprise, Livingston.
Mining World, Butte.
Journal, Milwaukee, Wis.
Madisonian, Virginia City.
Northwest Tribune, Stevensville.
Sentinal, Gebo, Mont.
Sentinel, Boulder.
Stock Growers' Journal, Miles City.
Tribune Review, Butte.
Tribune, Great Falls.
Western News, Hamilton.
Yellowstone Journal, Miles City.
The News, Libby.
News Letter, Plains.
Oregon Agriculturist, Portland, Ore.
Northwest Horticulturist, Tacoma.
Farmers Review, Chicago.
N. W. Farm & Home, N. Yakima Wash.
Ohio Farmer, Cleveland, Ohio.
Democrat, Lewistown.
Market Garden, Minneapolis, Minn.
Strawberry Specialist, Kittrell, N. C.
Swine Breeder's Journal, Lincoln, Neb.
The National Nurseryman, Rochester, N. Y.
Agricultural Epitomist, Indianapolis, Ind.
Ruralist, Federalsburg, Md.
Stockman and Farmer, Helena, Mont.
Success with Garden, Reed City, Mich.
Field and Stream, New York City.
Park and Cemetery, Chicago, Ill.
Rural New Yorker, New York.
The Farm Home, Springfield, Ill.
Orange Judd Farmer, Chicago, Ill.
Prairie Farmer, Chicago, Ill.
The News, Miles City.
Am. Gardening, N. Y.
Western Creamery, S. D.
S. Farm Magazine, Baltimore.
Dairy & Creamery, Chicago, Ill.
Farm & Poultry, Boston, Mass.

ROTATION PLATS FALL OF 1898.

The following is the result of the rotation plat yields:

Weight acre peas straw and fruit	6630 pounds
" " sugar beets	10060 pounds
" " clover	8079 pounds
Yield acre wheat	53.5 bushels
" " oats	81.26 bushels
" " barley	88.5 bushels
" " peas	28.1 bushels

There was a shrinkage in the pea yield, occasioned by the harvested crop while in windrows having been badly scattered by a heavy ind storm, the straw was rolled some distance and the peas were adly shelled out.

STATION FARM CROP.

ield farm crop per acre barley	72.8
" " " " " oats	51.9
" " " " " peas	41.6

In making comparison between the the rotation acre crops and the neral farm crops it should not be lost sight of that the average of the farm lands with respect to productiveness and fertility is not so good as the six acres embraced in the test plats, also that we have not been able to formulate and carry out in our general farm practice as complete a system of rotation of grain, root and legume crops as is practiced in the rotation tests. There is a marked difference in the yields especially considering that upon the farm crop area there were 9 acres well manured with barn yard manure, at the rate of fifteen loads to the acre. It will be remembered that no manure or fertilizer of any kind has been applied to the six acres rotation test tract, since the year before the rotation test was inaugurated and that the uniformly good farming, perfect tilth, judicious irrigation and more than all the powerful stimulus to grain production found in the preceeding legume (clover and peas) and root (sugar beet) crops.

GALLATIN COUNTY CROPS.

Average grain yields, Gallatin County, 1898.

Yield per acre,	winter wheat	30½	bushels.
" " "	spring wheat	31	"
" " "	oats	54	"
" " "	barley	43	"

We cannot obtain a fair comparison in these yields as many of the Gallatin crops were cut by hail, with attendant shrinkage of yields.

A very satisfactory condition is discovered in that the aggregate area of the clover, alfalfa and alsike meadows of those reporting exceed that of timothy by more than 50%. This is very encouraging as many or the legume meadows were cut for the first season, and will grow better with age.

A more gratifying showing even than the increase in legumes is that the area of summer fallow land has decreased more than 25%, however these conditions are but complements of each other, increased clover areas will always mean decreased fallow fields.

It is said that if white clover gets a start, it will spread, even as the value of clover meadows is understood, will they spread and costly hideous wasteful bare stretches of unproductive fallowed lar be replaced by the rank bush, money and satisfaction begetting clo fields.

Respectfully,

S. M. Emery, Directc

STREAM GAGINGS.

Appreciating the importance to the Station of possessing reliable data, relative to the water supply of eastern Montana, this Station has for five years past conducted yearly gagings of the following streams: the Jefferson, Madison, Gallatin, Missouri, Yellowstone, together with numerous smaller tributaries of the same streams.

In addition to these streams, gagings have been conducted of Sun River and Milk River. It has been pcssible to secure these measurements by the co-operation of the Station with the Hydrographic Division of the United States Geological Survey; the Hydrographic Division supplying instruments and defraying the expenses of the observers, whose business it is to secure the gage readings. In addition to this they have kept a resident hydrographer in the field during the period of open water, upon the streams. Complete records are preserved of the flow of water in these various streams, all measurements being reduced to second-feet, i. e. the number of cubic feet of water moving at the rate of a foot per second, this being the authorized department method for the computation of water flow.

The possession of this important data enables the Station to estimate quite reliably the amcunt of water available for irrigation in the territory in whioh gagings have been conducted during normal years.

REPORT OF THE HORTICULTURIST.

The winter of 1898 and '99 was a record breaker. It really began in September, upon the 4th the ground was white with snow in the Gallatin Valley, with a temperature of 32 degrees F. Sept. 8th.

Vegetation of all kinds was in full leaf, and totally unprepared for any such extreme. In October it was reported, that in the Bitter Root Valley. the present scene of the greatest activity in orcharding, the thermometer indicated 45 degrees below zero. A strange feature in connection with this low temperature is that the soil was not frozen to any extent prior to this sudden fall in temperature. Fruit trees, particularly budded stock set in the springs of '97 and '98 suffered severely. A prime essential to the well being of fruit trees under conditions of great severity of weather is to have made the current season a good healthy growth and to enter the winter with the wood fully ripened.

By an entrance into winter is not meant the months so indicated in the calender, but the time when the mercury falls to zero. Such weather sometimes occurs in September or October and quite uniformly by Nov. 15, often before the foliage has fully ripened and fallen and the wood matured., zero weather or even 6° above zero is in our judgment more harmful to fruit trees than would be 30 to 40 below zero in the dead of winter, particularly if such extreme has been reached by a sliding scale of constantly lowering temperature.

Again there is but little question that there is a material difference in the time of maturity of different varieties of apples and crabs, with a natural variation in hardiness of wood and ability to resist a sudden severe change of weather.

Desirous of setting an Experiment orchard on these grounds which would cover more comprehensively the field, 125 sorts were dug, 5 of a kind, beginning to dig by hand on Oct. 26 and the task being completed on Nov. 10. The average temperature of October was 29½° F., the maximum was Oct. 8th 63° F., the minimum Oct. 4th was 18½° F.

Tree digging did not progress every day during this period and was only conducted when it was favorable weather. Leaves were stripped by hand and the stock as rapidly as five trees were dug was carefully heeled in, later it was securely trenched in a dry spot, by a man experienced in such work. The trenches were opened in May, the stock taken ont, trenched and planted from May 5th to May 12th. Apparently all trees were in perfect order when taken out of the pit. They were set in rows 33 feet apart, trees 5½ feet apart, it being the intention to eventually leave but one of such varieties as would live. It was thought that in setting three to a rod, the rows two rods apart so that the spread of the tree would be toward the greater opening and that a fair test could be gained as to hardiness of tree and quality of fruit, and economy of land practised. The spring was backward ar cold and the buds started slowly.

It was noted as late as the 25th of June that a considerable numb had not then leaved out. Two irrigations were given them; on Ju 14th and July 18th. This still failed to start the buds, though t cultivations were frequent and thorough. But few of the now growi trees presented the wrinkled, shriveled appearance so common at t late date, to the tree which has failed to grow. Aug. 5, 1899 a co was made showing the following state of affairs. Recapitulations of the plantings have been made showing the varieties all of which made good growth, of those, all of which refused to grow, of those 4-5ths of which grew and of those 4-5ths of which died.

VARIETY.	ALIVE.	WEAK.	DEAD
Am. S. Pearmain		2	3
Arkansas Black			5
Alexander	4		1
Autumn Strawberry	5		
Arkansas Beauty	2		3
Alaska	5		
Allens Choice	5		
Black Twig,	5		
Bailey Sweet		2	3
Bordsorf	4		1
Ben Davis	3	2	
Baldwin		1	4
Belle De Boskoop			5
Coles Quince	4		1
Coffelt	3		2
Chenango Strawberry	2	1	2
Clayton	1		4
Carthouse	2		3
Canada Red	1		4
Charlotten-Thaler	2		3
Delaware			5
Domini	2		3
Duchesse	5		
E. Strawb. Apple	5		
E. Harvest	1		4
E. Red	1		4
E. Strawb. Crab	5		
E. Pennock	1		4
Flora Bell		3	2
Fameuse	2	1	2
Florence Crab	5		
Golden Russet	1	1	3
Greenwood	5		
Golden Beauty	5		
Grimes Golden	1		4
Gano	5		
Gravenstein	1		4
Gideon	5		
Haas	2	2	1
Hubbard Nonsuch			5
Hersey Sweet	2	1	2
Huntsman	1		4
Hyslop	5		
Hibernal	5		
Hurlbut	2		3
Hughes Virginia	1	2	2
Jonathan			5
Iowa Blush	2	1	2
Jacob Sweet	1		4

Ishams Sweet	1		4
King of Tompkins Co			5
Keswick Codlin		3	2
Liebe	3		2
Lady Elgin	2		3
Longfield	2		3
Lawver			5
Lansingburg	1	2	2
Lowell	1		4
Mann	1		4
McIntosh			5
McMahon	3		2
Minkler	2	1	2
Montreal	5		
Minnesota	3		2
Maiden Blush	1		4
Martha	5		
Milam	1		4
Mo. Pippen	1	1	3
Milton	5		
N. W. Greening	2	2	1
N. Spy	2		3
Orange	5		
Okabena	5		
Pumpkin Sweet	1	1	3
Price Sweet	4		1
Plumb Cider	4		1
Perry Russet	2		3
Pewavkee	3	1	1
Pride of Minneapolis	5		
Queens Choice	4		1
Roman Stem	1	1	3
Ramsdell Sweet	5		
Rolfe	2		3
Red Astrachan	3		2
Rubicon	3	1	1
Rome Beauty	3	1	1
Rawles Janet	1		4
R.I. Greening			5
Roxbury Russet		1	4
Rambo	1		4
Red June	1	3	1
Russet	5		
Red Bietigheimer	2		3
Ribston Pippin	1		4
Stark		2	3
Smith Cider			5
Salome	1	2	2
St. Lawrence		4	1
Smoke House		4	1
Sweet June	5		
Spitzen Berg			5
Stump	1	2	2
Seek No Further	1	2	2
Scotts Winter		1	4
Shockly			5
Tetofsky	2		3

Twenty Ounce		1	4
Transcendent	5		
Talman Sweet	4		1
Utters Red			5
Van Wyck	3		2
Virginia	2		3
Willow Twig	1		4
Winter Sweet	5		
Walbridge	8		2
Wine Sap	3		2
Whitney	5		
Wealthy	5		
White Arctic	4		1
Wolf River	5		
White Winter	4		1
York Imperial	5		
Yellow Bellflower	4		1
Yellow Transparent	5		
Yellow Newtown Pippen	1		4

We believe that it is fairly demonstrated in these results that the respective relative hardiness of the different varieties of apples and crab trees depend in large measure upon the ability of the tree to accumulate its proper store of material for bud formation early in the fall in advance of freezing weather, and that it is not the extreme cold that does harm, but such climatic changes as will suspend the assimilation of the proper food for future development of the tree. To sustain this theory we present below two groups, the first in which four-fifths or more of the trees have lived; the second, that in which four-fifths or more of the trees have failed to grow.

TREES OF WHICH FOUR-FIFTHS GREW.

Alexander
Autumn Strawberry
Alaska
Allen's Choice
Black Twig
Borsdorf
Montreal Beauty Crab
Martha
Milton Crab
Orange
Okabena
Price Sweet
Wealthy
White Winter Crab
Cole Quince
Duchess
Strawberry Apple
Strawberry Crab
Florance Crab
Greenwood
Plumb Cider
Pride of Minneapolis
Queen's Choice
Ramsdell Sweet
Russet Crab
Sweet June
White Artic Crab
Yellow Bellflower
York Imperial
Golden Beauty
Gano
Gideon
Hyslop
Hibernal
Transcendent
Talman Sweet
Van Wyck Crab
Winter Sweet Crab
Walbridge
Whitney Crab
Wolf River
Y. Transparent

TREES OF WHICH FOUR-FIFTHS FAILED TO GROW.

Arkansas Black
Baldwin
Belle de Boskoop
Clayton
Canada Red
Delaware
Ey. Harvest
Ey. Red
Ey. Pennock
Smith Cider
Spitzenberg
Willow Twig
Grimes' Golden
Gravenstein
Hubbard Nonsuch
Huntsman
Isham Sweet
Jacob Sweet
Jonathan
King of Tompkins Co.
Lawver
Lowell
Mann
Scotts Winter
Twenty Ounce
Yellow Newton Pippin
McIntosh
Maiden Blush
Milam
Rolfe
Rawles Janet
R. I. Greening
Roxbury Russet
Rambo
Ribston Pipyin
Shockley
Utters Red

In support of this theory there are perhaps in the first list only ten varieties out of forty-two which might be questioned as to being so called iron clad varieties, these are: Sweet June, Autumn Strawberry, Black Twig, Coles Quince, Gano, Plumb Cider, Ramsdell Sweet, Talman Sweet, York Imperial and Yellow Bellflower, while under the second list of thirty-seven trees there is not a single claimed "Iron Clad" variety; those coming the nearest to that class are perhaps as follows: Mann, McIntosh Scotts Winter and Utter Red. I am of the opinion that this generalization as to the iron clad would be indorsed by the nursery men and orchardists of the upper Mississippi valley.

In no single instance, we believe, has a variety failed to respond that has been classed as an iron clad, while a number of those classed as semi-hardy have stood better than others supposedly more hardy. Many of these trees are apparently in a perfect dormant condition, buds and young wood plump and full, and every promise of normal functions being renewed at an early date, spite of the lateness of the season.

The question arises, why have the trees which have not leafed out behaved thus, with no visible reason for such conduct? Unquestionably the severity of the fall and early winter caught them in an unprepared condition, and what constitutes an unprepared condition? It is a conversion of the sap of the tree into the constituent elements comprising food material for buds and leaves. This is largely starch and sugar and if the unreasonable cold arrested the development of these actors, we have a reason for this behavior.

Does this lateness of maturity constitute the difference between hardy and tender fruit trees?

Farther work will be prosecuted along these lines, seeking a solution of this vexed problem. Notes are being taken in apple blocks of two year roots and yearling tops to ascertain the relative maturity of new wood as indicated by the formation of the terminal buds.

It is noted that the younger trees require a greater length of time to develope this terminal bud and presumably to ripen the new growth of wood. In a comparison between yearling, two year and three year old wood, the oldest trees are found to mature the quickest and the two year trees more quickly than the yearlings.

An element of great encouragement is to be found in the behavior of different aged trees in Montana. Elsewhere, notably in sections of the humid states, the younger trees are the more resistant to climatic effects, while aged trees, those just coming into bearing or soon thereafter, show a marked tendency to succumb to climatic extremes.

Beyond question the reason for this difference is to be found in the practice of intelligent irrigation. In the humid regions, the roots of the younger trees are nearer the surface and experience the benefits of both surface moisture and cultivation, while as the tree develops its major roots pass down info a region beyond the immediate effects of rain waters and of cultivation. Such suffer from the dual deprivation and an enfeebled state or death ensues.

Under excessive, frequent and long continued irrigation both crowns and roots are powerfully stimulated and undue growth occasioned, this in turn does not mature in season and the young tree is injured by the occasional extremes of severe winter weather. The remedy for this condition is to be found in early planting, deep and clean culture, during the period of weed growth and temperate irrigation. Aged orchard trees in fruiting mature still more quickly than nursery stock.

Observation in California lead to the belief that our orchard area an be materially extended, by reducing the average amount of water s usually applied to the Montana orchard. That is to say, the Caliornian substitutes quite largely intensive culture for irrigation. The eason of '97 was practically rainless in much of the fruit sections of California and yet they experienced but little difficulty in keeping orchards alive. The Californian practises that which the average fruit rower of the United States does not.

For example, beginning with the setting of the fruit tree, intensive cultivation is inaugurated and maintained. This is not the shallow culture of the balance of the country but deep. The effort is made to discourage the formation of the shallow surface roots, that are common in any country where the tree depends upon frequent rains or repeated irrigations for growth. Deep cultivation in this case compels two things, deep moisture deposition, as when the rains come, or irrigation is performed, water speedily follows the deep furrow to still lower levels, and the tree roots go to the greatest source of water supply, which in this case is from 18 inches to 6 feet below the surface depending on the age of the tree and the character of soil.

Instead of encouraging the tree to grow shallow roots, as is always done either by shallow cultivation, repeated light irrigations or mulching, these are discouraged by cutting them off with the closely run deep furrows. Roots are bound to form upon a thrifty tree and failing to find lodgement in the first 12 inches of soil, they are compelled in self defence to hunt lower levels. The result of this deep rooting is manifestly to the advantage of the tree, in that it insures for it more permanent conditions of moisture and a steadier uninterrupted growth than happens to the tree whose roots are in a soil more susceptible to climatic changes, and not only do they force the tree to a system of deep rooting but they continue the cultivation until the dust mulch covers the soil surface not to a depth, of the two or three inches so commonly advised by eastern culturists, but to six or eight inches. Into this the foot of an adult will sink to the shoe top, not a weed or a spear of grass is visible, nor did I see any attempt at co-operative cropping of the land to other crops in the orchard. The land on which the orchard stands is religiously devoted exclusively to the use of the orchard. We of Montana may profitably study California orchard methods and put them into practise.

DORMANT TREES.

In using the term dormant, reference is made to a condition exis ing in certain trees dug in the fall of '98, buried through the wint and set in the spring of 1899, and which have still failed to come leaf, or to die, that is to say, the wood is still plump and green, a the tree presents every appearance of a tree at rest. Unquestionab the fact that these trees have been irrigated accounts for this pres condition, and did not the roots take up moisture from the soil and transmit it through the sap cells to the body and limbs, undoubtedly the trees would have shrivelled up and died long since. It is proposed to lay all, or a part of these trees down, protect with soil, and see if growth function will be resumed with the coming of another season.

In attempting to arrive at the cause for the singular behavior of the trees now dormant, the following course is being pursued throughout the late fall of '99: Weekly irrigations are given to two of six each of the varieties which have stood transplanting the best, and the poorest. This will be carried forward with a view to keeping the trees green and soft until the ground freezes too solidly for moisture to penetrate and after zero weather has been experienced, scions will be cut from both treated and untreated trees of the same varieties, so as to compare the relative conditions of the two sets of scions. Comparisons will be microscopic and by chemical analysis as well.

The scions will also be tested in the natural method, namely, associating them with root sections in the form of grafts, and testing them for growth. We are convinced that material loss has heretofore been sustained by Montana nurserymen who have not been sufficiently prudent in the time in which scions are cut from the parent tree.

Experience would teach that the best results are only to be attained from taking fully matured cions before there has been sufficient freezing weather to impair their vitality.

A root graft to do well should start growth in the form of callousing, weeks before being set; this implies that root grafting should be performed in the middle of the winter and the grafts carefully boxed in damp material; (perferably sand) in a cool cellar, that they should be set as early as the ground can be worked; and their condition be such that growth should ensue at the earliest possible moment in the spring, this, so that the desired size of the yearling graft should be attained by the middle of July leaving ample time thereafter for the new growth, (and all above ground will be new growth) to fully ripen before freezing weather sets in.

Whether it is desired to cellar root-graft or to top graft, (the latter operation being best performed between the period of bud swelling and leaf bursting) the cions to be used should be cut the previous fall, before zero weather is experienced. A safe rule to follow is to cut cions when the leaves have fallen and the terminal bud set. Immature soft, green wood will not produce a strong growth even if it starts at all.

If the sap cells of the cion are not fully developed and in condition to assimilate the sap supplied by the parent root piece, the result will be the excess strength or sap of the root will push forth buds from adventitious buds on the root, a seedling growth start therefrom and the cion growth be smothered out by the excess strength of the seedling tree instead of one the same as the cion.

The process of fruit production from root-grafting is so simple and easy of performance and ample results so easy of attainment that there should be much of this done in an amateur way. The apparent length of time required is a deterrent, but two years from the apple seed is sufficient time for the development of a nursery tree quite large enough to transplant.

CONDITION OF ORCHARD TREES IN SPRING AND SUMMER 1899.

The loss in the Station orchard trees was greater by far than in any year of its history. It should be borne in mind that many of these varieties set were destined to death when planted, it being against our judgment that they would live. Unfortunately this is the only way to demonstrate actually by personal experience, the relative merits of tree hardiness and while it may appear as a waste of time and money to set supposedly tender trees, yet the surest foundation of ultimate success is based on failure and if it can here be demonstrated that certain trees are valuable or otherwise, it will be money made rather than lost to the State at large. It is thought that considering the altitude, 4793 feet, of the Experiment Station grounds, that varieties doing well here will thrive well elsewhere throughout the state under as favorable conditions of soil, moisture, etc.

The loss of trees is not wholly due to severity of season or condition of the trees. An open ditch carrying off the college drainage, owing to unusual severity of the season, filled with ice, over-flow waters were carried down to and through the orchard, covering a large per cent of the orchard site, under the snow, with the drainage. This unreasonable irrigation could but prove harmful to the trees, and we attribute much loss to this account. The following list shows the condition of orchard trees:

APPLE LIST

Variety.	SET.	ALIVE.	DEAD.
Yellow Crimean	5	0	5
Red Queen	6	5	1
Grandmother	5	2	3
Gipsy Girl	5	3	2
Bogdanoff	5	4	1
Persian	5	2	3
Royal Table	5	4	1
12 M	5	4	1
Rambour Queen	5	0	5
No. 257	5	0	5
Borsdorf	4	1	3
Longfield	3	2	1
Wealthy	5	5	0
Alexander	2	2	0
Tetofsky	5	2	3
Arabskoe	2	0	2
Fameuse	2	0	2
Cross	1	0	1
Gideon	3	2	1
Veronesch	11	6	5
Anisette	4	3	1
Zuzoff	5	1	4
Aport	5	2	3
Baiken	5	0	5
Rosenhagen	5	0	5
Oral No. 11	5	3	2
Good Peasant	5	4	1
Lead 3 N	7	4	3
Walbridge	2	0	2
Northern Spy	2	0	2
Gravenstein	2	0	2
Veronesch. Rosy	3	0	3
Grime's Golden	2	0	2
Red Bietigheimer	2	0	2
Hurlbut	2	0	2
Fall Pippin	2	0	2
Ben Davis	2	0	2
*Golden Russet	5	3	2
Keswick Codlin	2	0	2
Red Astrachan	2	1	1
Haas	3	0	3
Okabena	3	3	0
Thompson's	24	1	23
Sutton Beauty	2	0	2
Maiden Blush	2	0	2
Duchess	5	3	2
Scott's Winter	3	0	3
Wolf River	3	0	3
Hibernal	3	3	0
St. Lawrence	2	0	2
Talman Sweet	2	0	2
Yellow Transparent	2	2	0
Pewaukee	2	1	1
	214	78	136

*These were purchased of Jewell Nursery Co., Lake City, Minn., for Golden Russet Apples, but proved to be the Sweet Russet Crab.

PEAR LIST.

Variety.	SET.	ALIVE.	DEAD.
Giffard	2	0	2
Frederick Clapp,	2	0	2
Flemish Beauty,	2	2	0
Tyson	2	0	2
Winter Nelis,	2	0	2
Anjou,	2	0	2
Boussock,	2	1	1
Doyenne d Ete,	4	0	4
Augouleme,	2	0	2
Sheldon,	2	0	2
Seckel,	2	0	2
Lawrence,	2	0	2
	26	3	23

CRAB APPLE LIST

Variety.	SET.	ALIVE.	DEAD.
Pride of Minneapolis,	3	1	2
Whitney,	5	3	2
Hislop,	2	2	0
Transcendent,	5	5	0
Greenwood,	3	3	0
Bailey's Crimson,	3	1	2
Martha,	3	1	2
Virginia,	3	0	3
Orange,	3	2	1
Early Strawberry,	3	1	2
	33	19	14

CHERRY TREES.

Variety.	SET.	ALIVE.	DEAD.
Yellow Glass	5	0	5
Orel No. 24	6	3	3
Slanka	5	3	2
Amarilla	2	1	1
Black Tartarian	3	0	3
Griotte Precose	5	0	5
King's Morello	5	0	5
Royal Duke	2	0	2
Wragg	3	0	3
May Duke	2	0	2
Lutovka	5	2	3
Griotte du Nord	5	3	2
Bessarabian	5	1	4
Ostheim	3	0	3
Windsor	1	0	1
Tradescant	2	0	2
Montmorency	2	0	2
E. Richmend	2	1	1
	62	14	48

APRICOTS.

Variety	SET.	ALIVE.	DEAD.
Gibb	3	0	3
Budd	3	0	3
Alexander	3	0	3
	9	0	9

PRUNES.

Variety.	SET.	ALIVE.	DEAD.
George Glass	3	0	3
Communia	8	3	5
Hungarian	15	0	15
	26	3	23

PLUMS.

Variety.	SET.	ALIVE.	DEAD.
Tatge	3	0	3
Spanish King	1	0	1
Wilson	1	0	1
Ogon	5	0	5
F. Garden	3	1	1
Yellow Veronesch	5	2	3
Maquequeta	5	0	5
Wild Goose	3	0	3
Rollingstone	3	0	3
Desota	8	2	6
Hawkeye	3	0	3
Lombard	2	0	2
Coe's Golden Drop	2	0	2
Fellemburg	2	0	2
Charles Downing	2	0	2
Riga No. 118	5	0	5
Moldovka	5	4	1
Wyant	2	0	2
Milton	3	0	3
Hammer	3	0	4
Pottawattomie	3	0	3
Yellow Glass	7	0	7
Wolf	3	0	3
McLaughlin	9	0	2
Weaver	3	2	1
Smith's Orleans	2	0	2
Green Gage	3	0	3
Bavay's Green Gage	2	0	2
Peter's Y. Gage	2	0	2
	100	11	82

In vacances occasioned by the death of orchard trees, these have been removed from time to time and others set in their stead.

The following is the record of such replaced tree:

Variety.	SET.	ALIVE.	DEAD.	DORMANT
Alexander	3	3		
Allen's Choice	7	6		1
Arkansas Black	4	0	4	
Ben Davis	12	8	0	4
Bietigheimer.	13	10	2	1
Carthouse	6	1	3	2
Charlottenthaler	14	13	0	1
Canada Red June	2	1	1	
Duchess	3	3		
Delaware	2	2		
Early Strawberry Apple	12	8	3	1
Early Harvest Apple	13	12	0	1
Fameuse	5	5		
Florence Crab	1	1		
Gano	9	9		
Haas	6	5		1
Hubbard	6	2	3	1
Hibernal	11	11		
Jonathan	5	3	2	
Liebe	4	4		
Lawyer	16	8	3	5
Longfield	4	3	1	
McIntosh Red	9	6	3	
McMahon White	7	6	1	
North West Greening	3	1	1	1
Northern Spy	14	10		4
Okabena	5	5		
Pewaukee	4	4		
Plumb Cider	11	9		2
Price Sweet	9	4	1	4
Ramsdell Sweet	6	3		3
Rawels Janet	10	5	3	2
Red Astracahn	16	14		2
Roman Stem	3	2	1	
Rome Beauty	2		2	
Scotts Winter	6	3	1	2
Spitzenberg	6	0	6	
Salome	8	5		3
Tetofsky	6	4	2	
Twenty Ounce	2		2	
Utter's Large Red	1	1		
Walbridge	15	7	1	7

THE STRINGFELLOW METHOD.

In the spring of 1898, the experiment was made of planting root-pruned trees according to the Stringfellow method. This in brief is cutting off all side roots close to the main root, leaving a club and planting very firmly at the usual depth or a trifle deeper. The top is also cut back in the same fashion.

Doubts were entertained as to the survival of the trees thus treated, the soil not being so warm as where this method was first introduced;

in Texas. Two year trees were used in the test; five trees each of the following were set, one each of the five, a fair average tree, was root-pruned and with this exception, all were planted practically under the same conditions. Allen's Choice, Charlottenthaler, Duchess, Deleware, Gano, Hibernal, Jonathan, Longfield, Lawver, Liebe, North West Greening, Okabena, Pewaukee, Plumb's Cider, Price's Sweet, Red Astracahn, Rawles Janet, Scott's Winter, Salome, Tetofsky. The following table will show the results as to dead trees of those set:

VARIETY.	ROOT-PRUNED TREES DEAD.	UNPRUNED TREES DEAD.
Allau's Choice		3
Charlottenthaler	1	1
Duchess	1	1
Delawaro	1	1
Jonathan	1	3
Longfield	0	1
Lawver	1	1
North West Greening	1	3
OKabena	0	1
Plumb's Cider	1	3
Price's Sweet	1	2
Red Astracahn	1	1
Scott's Winter	1	2
Salome	1	2
Tetofsky	1	

Of 20 root-pruned trees, 12 failed to come out alive in the spring of 1899; of 80 unpruned trees, 24 failed to come out alive in the spring of 1899; or three-fifths of the root pruned and three-tenths of the unpruned trees, were the respective percents of dead trees, or twice as many in proportion died that were root-pruned as of the unpruned trees.

Of the living root-pruned trees, the following will indicate their respective conditions:

Allen's Choice, strong vigorous growth, terminal buds not set, very green.

Gano, vigorous growth, terminal buds set but yet green.

Hibernal, fair growth, terminal buds set, but green and soft.

Longfield, fair, medium growth, terminal buds set but very green.

Liebe, very small irregular growth, terminal buds not set.

Okabena, tremendous growth, terminal buds set in fine condition.

Pewaukee, very strong growth, terminal buds set, but green and soft.

Rawles Janet, moderate growth, terminal buds not yet set.

The comparative success in planting trees thus pruned warrants farther experimenting along the same line, and such will be conducted on a much larger scale in the spring of 1900.

Stringfellow, (so named for H. M. Stringfield of Galveston, Tex., the introducer of the method) pruning seems to one educated on the old theory that the root is the tree, to be the most senseless idiotic plan that could well be devised, and yet *trees thus treated do grow*, and after all it is not much more unreasonable than to sow grain, expecting it to grow and to reproduce its kind, 20, 40 and in the Gallatin valley, at times, 100 fold.

The tree thus pruned should be not to exceed two years of age, and preferably one year from the graft. One attempting to thus start an orchard should have a knowledge of how to prune and trim a tree, so as to develop a strong shapely crown or head, though this knowledge should be possessed by all attempting to grow an orchard. The tree is by this system placed practically upon the same footing as a cutting, and those who have had experience in producing deciduous trees from cuttings know that the soft wood trees, which may thus be grown, can be produced of much finer quality from a cutting taken from the current years growth of wood, than can be from a rooted seedling of the same age. In the case of the cutting, the first step toward rooting is a callousing process, which is developed around the cutting at the intersection of the bark with the heart wood. This often times covers the entire butt of the cutting and is a series of granulations from which new hair-like roots are thrown forth in all directions from the common center. Set a seedling cotton-wood without root pruning and the result will be an extension of the tap root downward and into the soil in which plant-food is usually not so abundant as nearer to the surface. At frequent intervals along the tap root, side roots will be thrown, these and the tap root supplying nourishment to the stem. By cutting off the tap root of same tree many roots will radiate at right angles with the cutting, from its base and into much better foraging ground than will be found by the main root, the result is generally increased growth, compared to the tree set unpruned.

No doubt exactly the same process takes place with the root pruned apple tree, usually from three to six roots are cut off smoothly at the point where they leave the main root, each of these cut surfaces speedily granulate and myriads of fine hair rootlets are thrust forth all directions, seeking plant food.

In the mean time there is but comparatively little drain upon the roots, as the limbs have also all been pruned and the top shortened in to a heighth of from 18 to 24 inches, depending on the age and size of the tree. By the time the dormant buds are thus forced into action, the roots are ready to do their part and the tree is forced into speedy and symmetrical growth, always supposing its owner to be on guard to give it the right direction by intelligent control of the new growth.

Points in favor of the new method are economy of planting, much smaller holes being necessary, in fact the tree thus pruned can be well wet with a dibble. Economy of freight and packing, and the lessened risk of the importation of insect pests upon roots and limbs. We are not prepared to advise inexperienced planters to purchase trees thus pruned as they would be much more liable to be imposed upon in the matter of ill-conditioned stock, than if the roots and tops were present to show for themselves the condition of the tree to the purchaser.

In passing judgment upon the "Stringfellow" method, it should be borne in mind that the winter of '98 and '99, was the most severe in the history of the station, and that of the twenty varieties thus treated that but four of them could by any stretch of the imagination be classed with the iron clads. These we would name as the Liebe, North West Greening, Okabena and Tetofsky and the other sixteen would hardly rank with the semi-hardies. With a normal Montana winter, (one in which the minimum would have been, say 25 degrees) it is altogether likely that a larger percent of the root pruned trees might have survived.

STRAWBERRIES.

Strawberries are compared upon a different basis than that of previous years. Originally twenty-five plants of a kind were set and the conditions in this respect were the same. In the present beds (a part of which were set in the spring of 1897) and the balance in 1898, varying numbers were planted ranging from one to three hundred plants of a kind. The yield is therefore reduced to the basis of a single plant. From some unexplained reason the strawberry crop was not up to its usual measurement of production at any point within the state. The spring was unusually backward and cold, and during the period from first bloom to the last berry picked there was but a single week in which the days and nights were sufficiently warm to crowd growth. The two-year plants had much the better of the one-year plants in that they had become firmly established and had thrown out strong and abundant runners.

The old standbys show their value as reliable fruiters. This is notably so with Bederwood, Bisel, Barton's Eclipse, Grescent, Enhance, Mrs. Cleveland and Warfield, while in the case of Brandywine, which has heretofore done comparatively nothing in its life on these grounds, has yielded at the rate of 10⅓ ounces.

Brandywine is a staminate plant. By referring to page 78, Bulletin 16, it will be seen that it is bounded in the new plantation by open ground to the east, Enormous (pistillate) to the north, Enhance (staminate) to the west, and Crescent (pistillate) to the south.

The soil is practically the same as that in which it has been growing and the plants set in new beds were transferred from the old bed. It seems to have been an illustration of that freakishness which is at times characteristic of the strawberry.

No opportunity was afforded to farther investigate the susceptibility of the strawberry fruit to withstand frosts. After blooming we were again exempt from killing frosts, pending the ripening of the fruit. The evident requirement of the state for an ideal berry will be found in a late bloomer, a pistillate sort an abundant yielder of fair size, good color and firm of texture. Such a berry properly fertilized will be a welcome accession to small fruit growers. Too much emphasis cannot be placed upon the structure of a desirable shipping berry. Already there are growers in the state with twenty-acre plantations of strawberries, and distributing these at the rate of 10,000 quarts per acre, over a period of fifteen days, the period of the greatest fruitfulness, such a bed is capable of supplying many people. Early strawberries were in market in Bozeman, from Oregon, Georgia and California the present season, and if these growers found it profitable to ship from 1500 to 2500 miles the Montana grower can certainly venture a shipment to the twin cities 1000 miles to the eastward.

After being accustomed to the strawberry, consumers are loath to give it up and under irrigation and freedom from frosts, upon the fertile, justly adapted soils to berry growth, there can be a no more profitable undertaking by the faithful planter and cultivator than strawberries for market.

We at least owe it to ourselves to produce this most delightful o all fruits in such abundance that every family within the state may enjoy them to the fullest measure during their season.

Variety	Date of First Bloom.	Date of First Fruit.	Yield per Plant Ounces.	Age of Bed Yrs.
Jessie	June 17	July 10	2¼	1
Klickitat	June 13	July 10	7	2
Kingsworth	June 22	July 20	¼	1
Lehigh	June 18	July 10	2¾	1
Lady Thompson	June 25	July 14	¾	1
Lovett	June 17	July 10	5 29-72	2
Manwell	June 19	July 14	4 15-32	1
Murray	June 19	July 13	1 1-10	1
Marshal	June 19	July 12	1 15-24	1
Morgan's Favorite	June 19	July 17	2⅜	1
Mrs. Cleveland	June 19	July 10	11 13-25	2
Michigan B	June 21	July 20	1 1-16	1
Margaret	June 21	July 17	2¾	1
Ocean City	June 22	July 14	1 17-52	1
Ponderosa	June 19	July 14	2¼	1
Paris King	June 17	July 10	5 11-13	2
Patrick	June 17	July 12	3 3-40	2
Robinson	June 15	July 10	5⅛	2
Ruby	June 19	July 14	2 1-24	1
Ridgeway	June 24	July 17	8 3-5	1
Stayman	June 10	July 12	7	2
Sparta	June 17	July 10	1¼	1
Staples	June 10	July 10	2½	1
Swindle	June 17	July 17	5 4-5	1
Splendid	June 17	July 10	10	2
Sunnyside	June 21	July 17	2 13-48	1
Sunrise	June 19	July 12	3 1-6	1
Sanders	June 21	July 20	1 1-6	1
Satisfaction	June 20	July 17	8 16-20	1
Tennessee Prolific	June 17	July 10	5 5-6	2
Starr	June 26	July 20	⅝	1
W. M. Belt	June 24	July 20	3¾	1
Woolverton	June 26	July 20	8 21-24	1
Warfield	June 17	July 10	8 3-5	2
Tubbs	June 19	July 10	10	1

STRAWBERRIES.

The following are dates of first bloom of fruit and yields per single plant of Strawberries for 1899:

Variety	Date of First Bloom.	Date of First Fruit.	Yield per Plant Lbs,	Ounces.	Age of Bed Yrs.
Anna Kennedy	June 19	July 12		1½	1
Bederwood	June 9	July 10		1275-92	1
Bisel	June 9	July 10		14	2
Barton's Eclipse	June 16	July 10		8 28-40	2
Brandywine	June 19	July 19		10⅜	2
Blonde	June 20	July 17		4⅞	1
Bismarck	June 24	July 17		1⅝	1
Clark's Seedling (Known locally as Hood River seedlidg and the great market berry of Hood River Country, Ore.)	June 26	July 15	2	9⅝	2

Variety.	Date of First Bloom.	Date of First Fruit.	Yield per Plant Lbs.	Yield per Plant Ounces.	Age of Bed Yrs.
Clark's Early..........	June 20	July 15	5	1¼	2
Carrie..................	June 18	July 14		1⅛	1
Cyclone.......	June 17	July 10		7	2
Crescent................	June 10	July 10		8¾	2
Clyde....................	June 17	July 14		2 1-6	1
Droughth King..........	June 17	July 10		5¾	1
Enhance................	June 12	July 12		7½	2
Edith..................	June 19	July 17		1 9-20	1
Evans..................	June 20	July 14		2 1-24	1
Enormous................	June 20	July 15		1 47-79	2
Gardner................	June 17	July 10		6⅛	1
Gov. Hoard.............	June 17	July 10		9	2
Gertrude...............	June 18	July 14		2 11-56	1
Giant...................	June 19	July 12		2 9-16	1
Gandy Belle............	June 19	July 10		5	2
Hall's Favorite.........	June 21	July 14		6⅞	1
Ivanhoe................	June 10	July 10		5⅛	2
Jersey Market.....	June 19	July 14		2 35-64	1

S. M. Emery, Horticulturist.

Report of the Chemist.

S. M. Emery, Esq., Director Montana Exp. Station, Bozeman, Mont.

Dear Sir:—Following is a resume of the work of my department during the fiscal year just closed.

In all we have made three hundred thirty-three analyses more or less complete as the occasion demanded.

Some of this work was in co-operation with other departments or at the request of state officials and included the following materials—fodders, grain, flour, clay, sandstone, coal, iron ore, water, etc.

The work on sugar beets was continued with the usual encouraging results. A bulletin has been issued containing the analytical data so far as collected, with discussions and conclusions. There is no doubt that many sections in Montana offer strong inducements to the sugar beet manufacturers, for high grade beets, cheap fuel. pure water, good limestone and ready transportation are all procurable.

Our study of alkali soil presented in Bulletin No. 18 shows that while the "white alkali" is widespread in the state that its presence in the soil is in no way inimical to agriculture judiciously conducted. Careless methods of tillage and application of water are sure to be followed by the "rise of alkali" and of the ground water and consequent killing of crops.

A subject related to the alkali soil question is that bearing upon the character of water used for watering stock. In alkali regions much of the water is strongly impregnated with purgative salts and we are endeavoring to determine just how much can be tolerated without ill effects developing and, if possible, to suggest remedies.

Analyses of waters used for irrigating in various sections show that not nearly so much plant food is carried by them as was suspected and the necessity for conservation of the plant food of the soil is again forced upon us.

The State Commissioner of Agriculture, Labor and Industry furnished funds for the collection of samples of food sold in the state and we have collected and analyzed a large number.

The results of this investigation published in the annual report of the Bureau of Agriculture, Labor and Industry were so favorably received that a more complete investigation was planned for the coming year, the Bureau to furnish the funds for securing the samples and the Station Laboratory to carry out the analytical work.

Some preliminary work on poisonous plants has been conducted.

Co-operative analyses have been made for the referees of the Association of Official Agricultural Chemists and several articles on chemical subjects have been presented to chemical societies as contributions from the Station Laboratory.

Respectfully,
F. W. TRAPHAGEN.

Report of the Assistant Agriculturist.

To the Director:

DEAR SIR:—As Assistant Agriculturist to the Station I would beg to submit the following report for the year ending June 30th, 1899:

My work, which began on April 9th, 1898, was devoted almost entirely to the supervision of field experiments and the ordinary operations of the farm.

The field experimental work consisted of the following tests: With cereals, sixty-six varieties of spring wheat, forty-four of oats and twenty of barley. With legumes, twelve varieties of common field peas, four of cow peas and one of horse beans. Twenty-six grasses were also started. Of potatoes and field roots, there were tried, sixty-four different kinds of potatoes, and several each of sugar beets, carrots, mangolds and turnips.

As it had been decided to give the Campbell Soil Culture system a trial, the plat grains were handled by that method. By means of the Campbell system, grains are grown in rows twenty inches apart and are cultivated during the earlier stages of growth. In order to accomplish this, two implements especially designed for the purpose are necessary, these are known, the one as the Campbell combined drill and cultivator, and the other as the sub-surface packer. The drill possesses a light steel frame carrying the seeder attachment and has six shoes by which the grain is placed in the ground and these being twenty inches apart the machine covers a space of ten feet. In order to convert the machine into a cultivator the seeder-hose attachment and shoes are removed and sections of cultivators are substituted. These are of two kinds, one with round teeth for stirring the ground and one with wide spring steel teeth for tearing up weeds. The sub-surface packer is gotten up somewhat on the plan of the roller with a rotary motion but is designed to do its work rather underneath the surface than on top. The machine consists of a number of cast wheels about three feet in diameter placed side by side upon a steel shaft, but with a space of six inches between each at the circumferences. The rims of the wheels are brought to a point instead of having a flat surface, like to the wagon tire. This allows them to go down into the ground a short distance and pack the under surface rather than doing all the work on top. Large lumps on the surface are, however, pulverized.

The plat grains were sown on lands prepared by and with the implements just described. Each plat was given an area of one-fortieth of an acre and though some difficulties presented themselves in the variation among varieties still a given quantity of grain was distributed as evenly as possible on the areas given.

As soon as the grains were sufficiently large and evaporation began to take place rapidly, the cultivator was applied and used twice before the time of irrigation. In applying the water during irrigation, its tendency to follow the rows caused some washing of the loosened earth which was followed later by baking and some cracking. We believe, as a result of this work, that though this system does not combine well with irrigation, still it should prove of great service on arid lands where water is unavailable.

The following are the results of the grain tests :

SPRING WHEAT 1898.

No.	Name.	Period of Growth. Days.	Yield. Bushels.	Weight Per Meas- Bushel. Lbs.	Ozs.
1.	Glyndon 773	133	38.86	59	8
2.	Wellman's Fife	130	38.83	57	12
3.	Glyndon 691	130	38.5	59	14
4.	Glyndon 750	133	38.16	59	12
5.	California White	133	38.	56	4
6.	Wild Goose	130	37.83	62	
7.	Pringles' Champion	130	37.66	60	11
8.	White Chaff	124	37.5	59	15
9.	Gyndon 113	133	37.33	59	2
10.	Ladoga	125	37.	60	
11.	Glyndon 758	133	36.83	58	14
12.	Junket	127	36.83	56	13
13.	White Russian Square Head	130	35.83	58	11
14.	Summer Cob	136	35.66	58	
15.	Glyndon 748	133	35.60	60	
16.	Gneiss	134	35.5	57	
17.	Glyndon 774	130	35.33	59	
18.	Onyx	136	35.16	56	8
19.	Blue Stem	133	34.5	58	13
20.	Glyndon 650	130	34.33	60	
21.	Glyndon 852	133	34.16	58	11
22.	Deitz Red	133	33.83	59	6
23.	Glyndon 768	133	33.66	59	8
24.	China Tea	127	33.66	59	2
25.	Glyndon 715	133	33.16	58	8
26.	Glyndon 963	133	33.16	58	14
27.	Club	130	33.16	60	
28.	Augers' Canadian	134	33.16	58	4
29.	Chili	129	33.	59	
30.	Gypsum	134	33.	59	4
31.	Opal	136	33.	58	4
32.	Saskatchewan Fife	133	33.	60	8
33.	Blount's Hybrid	127	32.66	58	4
34.	Glyndon 692	133	32.16	59	
35.	Glyndon 761	133	32	58	6
36.	Bedford Hungarian	130	31.66	58	10
37.	S. D. 774	133	31.5	59	14
38.	Glyndon 135	133	31.33	59	14
39.	Nox 673	130	31.33	57	2
40.	Snow Ball	127	31.16	57	8
41.	Sutherlin	133	31.16	56	2
42.	Power's Fife	133	31.	55	14
43.	Bordeau	134	30.83	51	10
44.	Glyndon 676	134	30.83	58	10
45.	Bolton's Blue Stem	134	30.5	57	12
46.	McKissock's Fife	127	30.5	57	10
47.	Silver Fife	127	30.5	58	6
48.	Gold Drop	127	30.33	58	
49.	Kubanka	130	30.	61	4

No.	Name.	Period of Growth. Days.	Yield. Bushels.	Weight Per Measured Bushel. Lbs.	Ozs.
50.	Bart Trimenia	130	29.83	60	11
51.	Velvet Chaff	127	29.83	58	14
52.	Virden	133	29.83	58	4
53.	Blount's Hybrid	136	29.16	60	
54.	Glyndon 638	134	28 83	58	4
55.	Eldorado	134	28.66	57	
56.	Amethyst	134	28.	58	8
57.	Nox B	134	27.	59	10
58.	Red Fife	134	25.83	59	14
59.	World's Pure	133	24.83	58	
60.	Hungarian Mountain	126	24.66	57	6
61.	White Fife	134	24 16	53	12
62.	Glyndon 818	134	23.16	59	6
63.	Minnesota Fife	136	23.	52	6
64.	Glyndon 661	133	23.	60	
65.	White Colorado	136	22.66	59	8
66.	Black Bearded Centennial	134	21.73	56	2

OAT TESTS—1898.

No.	Name.	Days to Mature.	Yield per acre Bushels.
1.	Poland White	129	62.34
2.	Wide Awake	126	53.4
3.	Nebraska	129	49.04
4.	Golden Giant	130	47.95
5.	Black Prolific	129	46 4
6.	Archangel	128	44.29
7.	Siberian	128	43.95
8.	Great Northern	128	43.59
9.	Bavarian	129	42.5
10.	Lincoln	126	42.5
11.	Mogheda	126	40.32
12.	Bland's White	126	40.32
13.	Nameless Beauty	128	39.23
14.	Canadian White	132	37.78
15.	American Beauty	126	37.41
16.	Bavarian	128	35.6
17.	Bonanza	133	34.87
18.	Early Everett	126	34.87
19.	Yellow Giant	126	34.5
20.	Oderbrucker	129	34.18
21.	Siberian	133	33.14
22.	Victoria	129	32 66
23.	Black Tartarian	132	32.33
24.	American Banner	128	31 24
25.	Poland White	128	30.88
26.	American Best	126	30.88
27.	Jonette	133	30.15
28.	White Maine	126	28.33
29.	White Wonder	126	28 33
30.	White Danish	128	27 24
31.	Black Prolific	128	27.24

No.	Name.	Days to Mature.	Yield per acre Bushels.
32.	Chinese Hulless	129	26.88
33.	White Swede	128	26.88
34.	Henderson's Clydesdale	128	26.82
35.	Race Horse	128	26.5
36.	Scotch	128	26.82
37.	Progress	128	25.79
38.	Square Head	128	25.79
39.	Giant Yellow	132	25.48
40.	Impd. American	128	23.61
41.	American White	126	22.88
42.	White Schoenen	128	25.88
43.	Prize Cluster	126	21.72
44.	Badger Queen	128	19.98

BARLEYS—1898.

No.	Name.	Days to Mature. Days.	Yield Per Acre. Bushels.	Weight per Bushel Lbs.	Ozs.
1.	Smooth Hulless	112	47.95	61	6
2.	Guy Male	109	43.35	56	4
3.	Delnorte	119	39.	61	6
4.	Black Hulless	112	36.08	63	12
5.	California Prolific	121	34.63	46	12
6.	New White Hulless	112	35.84	64	
7.	Winnipeg	112	33.9	62	
8.	Hungarian	119	32.	57	12
9.	Nepaul	120	31.75	56	
10.	Goldenthorpe	119	31.25	51	6
11.	Manhattan	121	30.51	45	14
12.	Manshury	120	28.75	45	12
13.	Italian	119	26.5	47	
14.	Imported Cheyenne	121	24.94	46	
15.	Highland Scotch	120	24.75	47	4
16.	New Zealand	120	24.75	44	8
17.	Champion	119	24.18	48	14
18.	Six Rowed	121	23.49	41	6
19.	Black Hulless	112	22.5	60	2
20.	Chevalier	120	21.55	46	12
21.	Kimma Kulla	121	20.48	45	

Though the yields given are not relatively large, still, the uniformity of the system used gave accurate comparative results. The low test per bushel, by weight, running throughout the list is accounted for largely by the washing followed by rapid evaporation and consequent hurried ripening. The barleys, also had the disadvantage of having been sown on very shallow ground.

The grasses, twenty-six in number, did not more than nicely make a start during the season. Owing to the large amount of other work they were not sown until June 13th, thus losing the benefit of the rainy season and encountering the most unsuitable conditions for germination. Some started at once, however, while others did not come for many weeks. Fairly good stands of each were obtained which will yield results in future. Among those to start most readily under the adverse conditions were Austrian Brome, Native Rye and Orchard grasses.

The potato and root crops gave remarkably good results considering the fact that the thres weeks of continuous rainfall delayed their planting until about the end of the first week in June. Sixty-four varieties of potatoes were tested and will be reported on fully when notes relating to quality can be furnished in addition to those of yield. Several varieties of sugar beets were also grown and samples used for analysis by the chemical department.

A small area of two or three acres of rape was grown as forage for sheep. While it grows well under the local conditions, still, it manifested a strong preference for rich loamy soils, and was susceptible to the attack of the aphis where grown on heavy clays. While this plant has proved to be a very useful forage plant in the east we do not believe it can occupy the same range of usefulness in Montana, except in favored localities.

During the winter season, feeding trials were carried on with lambs, to determine the relative values of alfalfa, red clover and alsike as fattening foods. The cost of production, with local food supplies, using the common stocks of the country was also studied. This work has been reported in detail in bulletin No. 21.

Respectfully submitted,
R. S. SHAW,
Asst. Agriculturist.

Report of the Zoologist and Entomologist.

To Director S. M. Emery :

DEAR SIR :—As Zoologist and Entomologist to the Montana Agricultural Experiment Station I took up my duties on the 20th of June, 1899, and have, therefore, been connected with the institution only ten days. This time has been spent in collecting, labeling and mounting insects in Bozeman and vicinity and in preparing plans and specifications for office and laboratory furniture, including a case to contain an insect collection. Orders for necessary supplies and apparatus have been sent in.

A preliminary study of the conditions in Montana as regards injurious insects and other animals has been taken up for the purpose of learning what lines of work are most needed. It is designed during the coming summer to visit as many parts of the state as possible and begin a study of the injurious insects.

Respectfully, R. A. COOLEY,
Zoologist and Entomologist.

Report of the Botanist.

BOZEMAN, Montana, June 30, 1899.

S. M. Emery, Director Montana Agricultural Experiment Station :

DEAR SIR :—I herewith submit my report for the year ending this date.

The first work of the year was the arrangement of the new rooms in the Station building and fitting them up for a herbarium and laboratory for botanical work. Realizing that future success in botanical work must depend primarily upon a large and accurately named herbarium, a great part of the year has been devoted to the arrangement of the various detached collections under orders and genera convenient for reference and to mounting and distributing the different unmounted collections so that the herbarium now contains some 4000 sheets, being especially full in the grasses.

Inasmuch as the agricultural and horticultural conditions of the state are dependent on the same conditions of soil, temperature, moisture, exposure and altitude, which determine the different plant formations of our native flora and the distribution of the various species, it is believed that the native plants may be made to serve as an index to indicate the suitability of a given region for particular crops or fruits by the *ecological* grouping of the flora according to conditions of growth and the correlation of these groups (plant formations) with known biological zones of cultivated plants ; hence the study of the various biological zones of the state with their native and cultivated plants is of prime importance.

It has been necessary first to familiarize myself with the native plants and learn those useful or noxious in the field and farm as well as to become acquainted with the various agricultural conditions of the state. Numerous excursions were made in the region about Bozeman and one to the basin about the West Fork of the Gallatin for the purpose of collecting specimens for the herbarium and to study possible forage plants, the forest trees, the weeds and parasitic fungi of the region.

The efficiency of this department must depend, in great part, upon the ability to study the economic and biological conditions in the various parts of the state, and it is hoped that means may be provided for this purpose. The work of the department has been greatly hampered and its natural growth impeded by the crowded condition of the rooms available for botanical work; more room is absolutely necessary in the immediate future. Respectfully,

J. W. Blankinship, Botanist.

630.679
M9eb,

UNIV. OF MICH.
JUN 1 1909

BULLETIN NO. 25

MONTANA

AGRICULTURAL EXPERIMENT STATION

...OF...

THE MONTANA COLLEGE OF AGRICULTURE.

PARIS GREEN AND LONDON PURPLE IN MONTANA.

BOZEMAN, MONTANA, APRIL, 1900.

BOZEMAN, CHRONICLE,
Bozeman, Montana,
1900.

MONTANA AGRICULTURAL
EXPERIMENT STATION.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman
Peter Koch, Secretary and Treasurer	Bozeman
George Kinkel, Jr., Vice-President	Manhattan
Walter S. Hartman	Bozeman
John M. Robinson	Bozeman

EXPERIMENT STATION STAFF.

S. M. Emery	Director and Horticulturist
F. W. Traphagen, Ph. D., F. C. S	Chemist
Robt. S. Shaw, B. S. A	Agriculturist
J. W. Blankinship, Ph. D	Botanist
R. A. Cooley, B. Sc	Entomologist
Samuel Fortier, Ma. E	Irrigation Engineer

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director,

Montana Experiment Station,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Received from Hist. & Miscellaneous Library 7-1-09.

Montana Experiment Station.

Bulletin No. 25. - - - **April, 1900.**

PARIS GREEN AND LONDON PURPLE IN MONTANA.

F. W. TRAPHAGEN.

It affords us great pleasure to be able to announce that the various brands of Paris green on the Montana market are, so far as our experience goes, of uniformly high grade.

Reports have been current that the Paris green on sale in this State is of poor quality.

These reports probably owe their origin to the circulation of bulletins from some of our sister states, where such conditions exist as would justify predictions of the existence of similar conditions in other states, particularly where there are no legal standards for the article, as is the case with us.

The sub-joined table shows that not only is the arsenious oxide present in percentages much above fifty per cent, which has been adopted as the minimum amount allowable whenever the matter has been legislated upon, but that in addition the arsenic is nearly all combined in insoluble form and hence will not injure vegetation when applied in not too great amount.

TABLE OF ANALYSIS OF PARIS GREEN AND

Serial No.	Dealer	Manufacturer	Price in Cents Per Pound
			PARIS
1167	W. D. Story & Co., Park City.	John Lucas & Co., New York, Philadelphia, Chicago.	35
1168	W. D. Story & Co., Park City.	Manufacturer unknown.	30 (bulk)
1169	R. F. May, Bozeman.	Acme Color Works, 100 William St., New York.	25
1170	Roecher & Alward, Bozeman.	A. B. Ansbacher & Co., New York.	25
1171	Osborn Drug Co., Bozeman.	F. W. Devoe & Co., New York.	25
1172	Lee Warren, Bozeman.	C. T. Raynolds & Co., New York.	30 (bulk)
			LONDON
1176	Lee Warren, Bozeman.	C. T. Raynolds & Co., New York.	40 (bulk)
1177	Osborn Drug Co., Bozeman.	Manufacturer unknown	15 (bulk)

LONDON PURPLE ON SALE IN THE MONTANA MARKET.

	Per Cent Copper Oxide	Per Cent Total Arsenious Oxide	Per Cent Combined Arsenious Oxide	Per Cent Free Arsenious Oxide
GREEN.				
	30.26	57.17	55.93	1.24
	29.98	59.52	58.43	1.09
	29.68	60.26	58.97	1.29
	31.08	57.67	56.63	1.14
	31.36	57.42	56.58	0.84
	30.80	59.40	58.31	1.09
PURPLE.				
		51.43	50.89	0.54
		37.18	34.51	2.67

The largest amount of soluble arsenious oxide found in any sample of Paris green, was one and twenty-nine hundredths per cent, while in samples reported from California as much as twenty-three and six-tenths per cent of soluble arsenious oxide was found in one sample.

Another sample showed six and seven-tenths per cent.

There can be no doubt that injury to vegetation would result from the use of either of these California samples.

Paris green is a definite chemical compound, and when pure should contain fifty-eight and sixty-five hundredths (58.65) per cent arsenious oxide, thirty-one and twenty-nine hundredths (31.29) per cent copper oxide and ten and six hundredths (10.06) per cent of acetic acid. The samples of Paris green on sale, unless intentionally adulterated, will not show a composition greatly at variance with the theoretrical composition given. Inasmuch as the presence of free arsenious oxide, in quantities above, perhaps, four per cent, is objectionable, the following simple tests quoted from Bulletin No. 126 of the California Experiment Station, are given in order that the purchaser may satisfy himself of the purity of his purchase:

"Ammonia test—Paris green dissolves freely and wholly in ammonia, becoming a beautiful blue liquid; while a majority of the substances formerly used in adulterating Paris green are insoluble. This, therefore, is a very ready means of recognizing most of the crude forms of adulteration. If upon treatment with ammonia any of the material fails to dissolve, the sample is adulterated. This test, however, is not conclusive, since white arsenic and a number of other substances used in adulterating Paris green, especially in these later years, are soluble in ammonia and would escape detection if this method alone were depended on. Ammonia then affords valid grounds for rejecting a sample if any portion of it is insoluble; but other means must be used to be sure of its purity, even if apparently pure by this test.

"Glass test—A very simple test, which will enable one to distinguish quite a good proportion of adulterated samples at once, including many of those not detectable with ammonia, is to take a very small portion of Paris green—what one could easily pick up on the point of a penknife—place this upon a piece of glass at an angle; jarring the lower edge will cause the little pile of green to move down the inclined surface, leaving behind it a bright green track, if the sample is pure; but in the case of many adulterated or impure samples, the track would be white or pale green. * * * * * * The glass test is particularly useful in comparing a number of samples, and after one has acquired some experience it becomes quite reliable. It does not enable one to detect the recent forms of arsenic adulterations, and, like the ammonia test, should never be considered as conclusive evidence of purity."

London purple, on the other hand, is a waste product of aniline dye manufacture and has no constant composition.

On this account one cannot be certain what amount of arsenic he is using at any time, for the samples differ very greatly. Of the two samples shown in the table, one contains fourteen and a quarter per cent more arsenious oxide than the other. Unless some guarantee of its composition is given, it would be much better to avoid the use of London purple, for without such knowledge one cannot know, even approximately, the strength of the insecticides he is applying.

Formulas for the application of these insecticides, will be found in Bulletin No. 23 of this Station, on Insects Injurious to Fruits by R. A. Cooley.

In conclusion, we may quote the following few words, as showing very fairly the conditions existing in Montana:

"In general, it may be said that the results of our work indicate a very satisfactory condition as to the purity of the Paris green in the market. They do not justify the widespread belief that Paris green is extensively and seriously adulterated. In every instance the arsenious oxide considerably exceeds the legal requirements."

Bulletin No. 165, New York Agricultural Experiment Station, P. 228.

630.679
M19eb

BULLETIN NO. 26.

UNIV. OF [illegible]
JAN [illegible]

Montana
Agricultural
Experiment Station

......OF......

THE MONTANA COLLEGE OF AGRICULTURE.

POULTRY RAISING.

BOZEMAN, MONTANA, APRIL, 1900.

ROCKY MOUNTAIN HUSBANDMAN
White Sulphur Springs,
MONTANA.

Montana Agricultural

EXPERIMENT STATION.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman.
Peter Koch, Secretary and Treasurer	Bozeman.
George Kinkel, Jr., Vice-President	Bozeman
Walter S. Hartman	Bozeman
Jno. M. Robinson	Bozeman

EXPERIMENT STATION STAFF.

S. M. Emery,	Director and Horticulturist.
F. W. Traphagen, Ph. D., F. C. S	Chemist.
Robt. S. Shaw, B. S. A.	Assistant Agriculturist.
J. W. Blankinship, Ph. D.	Botanist.
Samuel Fortier, Ma. E.	Irrigation Engineer.
R. A. Cooley, B. S.	Entomologist.

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

Montana Experiment Station,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana (so long as the supply lasts) who sends his name and P. O. address to the Station for that purpose.

MONTANA EXPERIMENT STATION.

Bulletin No. 26. *April, 1900*

POULTRY RAISING.

By H. C. GARDINER, Student in Charge.

The object of this bulletin is principally to foster the interest in poultry raising which is gradually awakening in Montana, by giving in a condensed form such information about the industry as will be of practical value to those who raise poultry, either for marketing or for home consumption, and to outline the work of this department since it was instituted about a year ago, and also to include a description of our equipment and an outline of future work.

EQUIPMENT.

The equipment is as follows:

The main building, 72 by 14 feet, erected November, 1899.

The brooder house, 36 by 14 feet, erected April, 1900.

The log house, 45 by 12 feet.

An incubator cellar, incubators, brooders and brood coops.

The main building is designed for breeding purposes, and is divided into six pens 10 by 12 feet each, with a four foot passage in the rear. It has a double floor space giving an area of 2016 square feet.

The brooder house is designed for brooding chicks in the spring months, and is utilized in the fall and winter for experimental feeding pens. It is divided into seven pens, each 5 by 10 feet, with a four foot passage in the rear.

The log building is used for experimental purposes and surplus stock, and is divided into four pens, with a three foot passage in the rear.

The incubator cellar, 14 by 36 feet, is situated under the farm house, and is found to be a very suitable room for the puspose, as the temperature is fairly constant, and the ventilation good; outside changes affecting it but slightly.

We are using two makes of incubators, two Cyphers and one Monarch. All the hatching is done with these machines, the Cyphers doing the better work and requiring a minimum amount of care, owing to the simplicity of regulation.

The brooders are of our own manufacture, and serve their purpose very well. Their construction will be described later. The brood coops, 3 by 4 feet, are used for the chicks after they leave the brooders. These coops are movable, so that the young birds may be colonized as desired.

BREEDS.

The subject of breeds is really a question of the suitability of the fowl to climatic conditions and of the demands of the market, or of the personal fancy of the owner.

Barred Plymouth Rocks, White Wyandottes and Rose Combed Brown Leghorns are the three breeds kept at the Station, and in the writer's opinion, these three classes possess to the greatest extent the characteristics which should make them the birds for the farmers of this State to raise.

The Plymouth Rocks are good general purpose fowls, as they are good winter layers and possess all the desirable qualities of good table fowls. They lay, it is estimated, under favorable conditions, 175 eggs a year, which will average 8½ eggs to the pound. Constitutionally they are hardy, good foragers, and stand confinement fairly well.

Standard weights: Cock, 9½ lbs.; cockerel, 8 lbs.; hen, 7½ lbs.; pullet, 6½ lbs.

The White Wyandottes possess practically the same characteristics as the Barred Plymouth Rocks, but are as a rule about a pound lighter, maturing about three weeks earlier than the Plymouth Rocks, this making them especially valuable as broiler birds. Their average egg yield is a trifle below the Plymouth Rock, but the eggs average a trifle heavier, going about 8 to the pound. Constitutionally they are not as hardy as the Rocks, and we have found the chicks harder to raise than either Plymouth Rocks or Brown Leghorns. They are good foragers, but with us do not stand confinement as well as the other breeds.

Standard weights: Cock, 8½ lbs.; cockerel, 7½ lbs.; hen 7½ lbs.; pullet, 5½ lbs.

The Rose Combed Brown Leghorn is the egg machine, and in our estimation is one of the very best breeds there is for money making. They are vigorous, hardy, and active, stand confinement very well, and with us lay very plentifully, even in the coldest weather in winter. They will, as a rule, produce more eggs in a year than the heavier breeds, averaging 190 eggs annually, and where eggs are sold by the dozen as they are here, numbers are most essential.

Standard weights: Cock, 5 lbs.; hen, 4 lbs.; cockerel and pullet, no standard.

INCUBATION.

Wherever poultry keeping has become a prominent feature in farming operations it has almost invariably been the rule that incubators have heen introduced. This is essential since chicks can then be hatched in time for the early broiler market and in time for the pullets to mature for fall and winter laying. Another profitable feature is the saving of attendants' labor and of the hen's time. Three hundred and fifty eggs are as easily managed in an incubator as thirty-five eggs under three hens.

In operating an incubator to the best advantage it will be found that even with the best machines the most accurate regulation of heat in the egg chamber is to be had in a room where the temperature is constant and the ventilation good. A cellar is about the best place as a rule, that can be found. Good ventilation is essential since the little chicks require a considerable amount of oxygen for the vital functions, and the lamp of the machine exhausts the supply in its immediate vicinity where the ventilation is imperfect.

The following are a few points which are worth observing in the running of any incubator:

1. Read manufacturer's directions and *comply with them.*

2. Set the machine up level and see that it *remains level.*

3. Do not allow a draft in the machine.

4. Use good oil, and trim the lamps at least once a day, and oftener if the oil is poor.

5. Remove infertile eggs and dead germs on the sixth or eighth day and test again about the fifteenth day.

6. The second day commence turning the eggs twice a day, morning and evening, at regular intervals, and continue the turning until the eighteenth day.

7. Run the machine at 102½ degrees throughout, allowing the temperature to run up just before hatching to 104 or 105 degrees, if it is inclined; not endeavoring to check the rise until it gets beyond 108 degrees, its maximum, which temperature will not be too high when the chicks are coming out rapidly.

8. Under no ordinary circumstances should the machine be opened when the chicks are hatching. It is of the greatest importance that the temperature and humidity should remain constant at this particular time, and none of the chicks should ever require any assistance in leaving the shell. Should the machine be opened the rapid evaporation causes a sudden cooling of the egg chamber aud also dries it off so that many chicks just pipped stick to the shell and do not hatch.

When the hatching is well over the machine should be opened and the unhatched eggs removed. It is our practise to allow the chicks to remain in the machine for the first twenty-four hours at a temperature of 90 to 94 degrees, transferring them to the brooders about the time they should receive their first feed.

BROODING CHICKENS.

It is very important that the temperature of the brooder should be constant. Starting with a temperature of 90 degrees F., lowering it a half degree a day for the first week, after that lowering it a degree a day. Cleanliness is also of primary importance, and dry earth (road dust preferably) should be dusted over the brooder bottom. The most difficult feature of rearing chicks in brooders is to get them to take exercise enough. Last spring we found that it was very important to exercise from the very first day if the most vigorous growth was to be secured. The easiest way to get them exercising is to feed cracked wheat, rolled oat-meal, or granulated oats in a little chaff where the chicks will scratch for it.

In feeding brooder chicks the method of feeding is of more importance than the kind of feed. Chicks require to be fed frequently and in small quantities. It is fatal to the vigor of a chick to be overfed, and overfeeding is productive of loss of appetite and sickness. Brooder chicks should be fed five times a day for the first ten days, and after that four times a day until a month old, when three times a day is sufficient. Their first feed should consist of fine gravel, followed by stale bread-crumbs and hard boiled eggs, (infertile eggs saved from the machine). This feed should serve for the first few days, when cracked wheat, boiled vegetables and meat, oat chop, bran and green clover cut fine should be given, and as the chicks grow older whole wheat and oats may take the place of cracked grain. Green bone fed in small quantities daily is also a very good addition and should always be perfectly fresh. Milk is also a valuable addition, and for young chicks should be fed mixed with meal, while with the older chicks it is best used as a drink. The aim should be variety, and meat and vegetables should be equally as important as grain. Chicks should not be overfed, nor receive food that is sloppy, sour or mouldy. The best results will be secured when they receive a good variety of fresh, wholesome food at reasonable intervals. With machine hatched chicks very little loss occurs from vermin, but with hens it is a very difficult matter to be free from this pest. The heads of the young chicks should be greased occasionally with carbolated vaseline, and the bodies dusted with Pyrethrum (Persian Insect Powder). Care should also be taken to dust the mother hens with Pyrethrum at the same time.

GENERAL MANAGEMENT.

A comfortable building is very essential before any considerable degree of success may be attained with fowls, and in order to secure this end the building should be situated facing the south, with plenty of windows for the admission of sunlight, It must also be dry; dryness is very essential, and although warmth is desirable, still where ventilation is good and the building dry and free from draft the birds will lay very well even in the coldest weather.

It is our aim here at the Station in caring for fowls during the winter to provide them with a variety of feed and plenty of exercise in securing it. Our method of feeding is as follows:

Morning—A mash (warm preferably) composed of boiled beef scraps, milk, vegetables and a little pepper and salt. This is made dry and crumbly by the addition of bran and oat-chop and is fed as soon as the birds are off the roost. It is very important to feed but very little of this mash, for if the birds eat their fill they will stand around and not exercise; on the other hand if their fast is just partly broken they will busy themselves scratching in the litter. After this soft feed a little grain is thrown into the straw and they receive a mangold or a head of cabbage. This feed keeps them busy until noon, when a little more grain is thrown in, with some clover chaff and a little ground green bone (about an ounce of bone apiece). The evening feed is whole grain, wheat or oats, also fed in the litter. In this way we keep the birds exercising almost constantly, insuring good health and freedom from the evil habits of feather and egg eating. Grit and dust are also supplied, and plenty of fresh water. It is a good practice to add a few drops of kerosene or carbolic acid to the drinking water as they are good preventatives against colds and disease.

CLEANLINESS.

Freedom from vermin is only possible where birds have free access to dust baths, and where the quarters are kept clean. With convenient arrangements roosts may be cleaned with little loss of time, once or twice a week, and the litter should be removed and fresh put in every three weeks. Filth and vermin promote disease and must be guarded against. Whitewash (use fresh lime in making whitewash) is one of the very best safeguards against these evils, and the building should receive a coat at least twice a year. It is best applied with a spray pump, but a brush and pail will serve very well. Roosts, nest boxes and other fixtures around which lice are apt to harbor should be sprinkled occasionally with kerosene, special care being taken to soak the cracks.

BREEDING BIRDS.

In any flock, whether pure breed or not, it is very desirable to select a number of the best laying hens and put them with the best male bird that can be secured. In this manner any flock can be improved, since the effect of selection will certainly be felt on the progeny. It is desirable to have the male bird with the hens only during the breeding season, as it has been found by experiment that hens lay more eggs

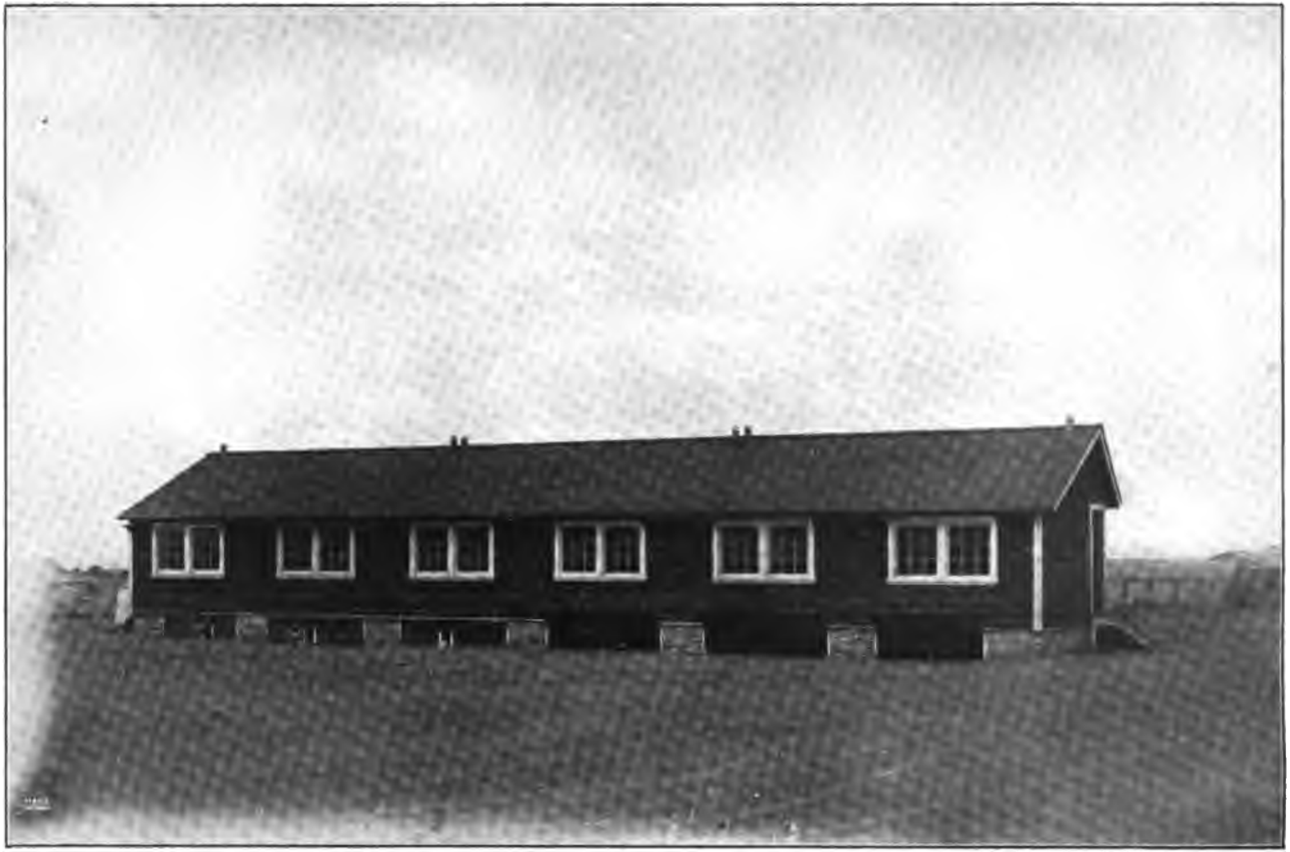


Fig. 4.- The Station Poultry Building.

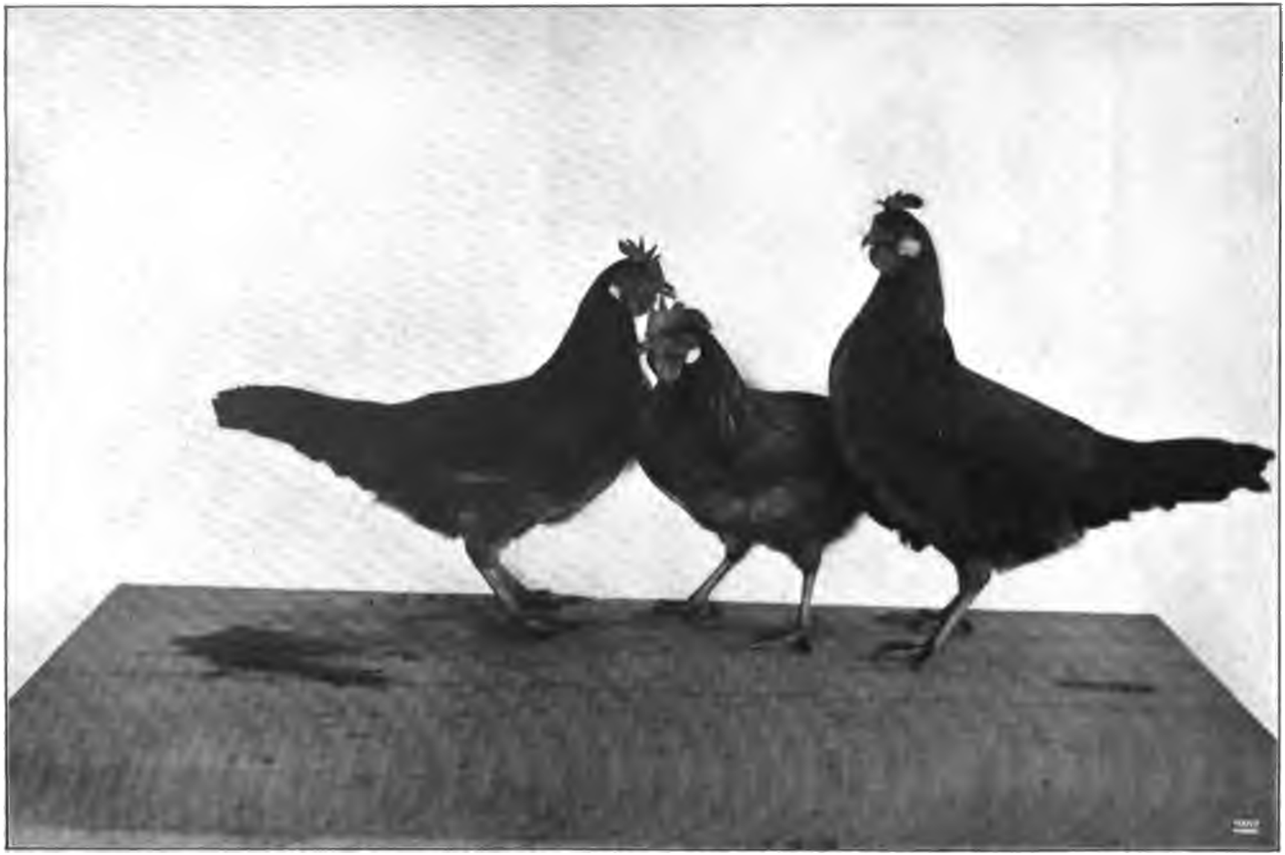


Fig. 3.- Brown Leghorns

The property of the Station.

without than with the male, and is also a considerable advantage to the eggs since the chief cause of bad eggs is the fact that the germ has started and then decay sets in. Breeding birds should receive all the freedom and exercise possible, and meat and vegetables should form a large portion of their diet. The vigor of the chick depends largely upon the past history of the parent bird, and in order to secure the required vigor of the germ the breeding stock should receive the best treatment possible. The number of hens to the cock is a point in which there may be considerable variation. Where birds are enjoying their freedom one male to from eighteen to twenty-two hens is sufficient in the Mediterranean varieties. while in the Asiatics and Americans one to twelve or sixteen should be the rule. It must be kept in mind, however, that the vigor of the male bird and the conditions under which fowls are kept should be carefully considered, and where birds are closely confined the number of hens to the cock should be considerably diminished, say a dozen to eighteen in the lighter breeds and ten to twelve in the heavier breeds. We found last spring that from the pens which produced the fewest eggs the percentage of fertility was the greatest, and the percentage of dead germs the lowest, so that it is obviously important that the number of hens to the cock should be studied carefully and the individual birds carefully selected with due regard to their vigor.

ADVANTAGES OF PURE BRED STOCK.

It is advisable when investing in the poultry business to select the best specimens obtainable of the breed which is particularly adapted to the trade which is to be catered to, and this selection should be very carefully made since the future of the business depends to a considerable extent upon this selection; There are, too, many other advantages in getting one good breed and sticking to it. The surplus cockerels from such stock may be disposed of for breeding purposes and at prices ahead of market values. Surplus eggs, too, may be sold for hatching at prices considerably in advance of eggs for table use.

We do not wish to convey the impression that average mongrel stock will not respond fairly well to good treatment and pay well, but we wish to emphasize the fact that for very little advance in original investment a breed of birds may be secured which have for generations been selected because of special fitness either as layers, meat producers, or both. And we would state most emphatically that pure bred stock is a better money maker since where one is keeping fowls with some special purpose in view a variety of fowl can be selected which unquestionably is better fitted for the work than any mongrel could be expected to be.

BUILDINGS.

The choice of a suitable location for the poultry house is of considerable importance. Since labor is such an important consideration in this business a convenient location is extremely desirable. The building should be situated on light sandy ground with a southern exposure, and it is very important that the situation be dry and the lay of the land such that drainage or irrigation of yards is easily accomplished. Dampness is conducive to disease and should always be avoided.

For flocks of twenty birds pens 10 by 12 feet are sufficiently large, and the length of the building should increase in exactly the same ratio as the number of fowls kept. For a flock of fifty birds we would recommend a building 14 by 24 feet, with a central passage way running from front to rear. This is a considerable saving of space over a building in which the passage way runs the whole length of the rear. In larger buildings this is not practicable and the passage should extend the full length of the house to facilitate feeding, watering, cleaning the pens and gathering eggs.

With regard to the direct construction some foundation should be used, not necessarily high, but sufficient to protect the building. In the construction of this wall, stone is to be preferred. When building upon a slope a few inches would be sufficient in the rear, making the front the height required. The sills should be bedded in mortar putting the joists upon them two feet between centers. Next the floor should be laid on the joists, it is best made with rough lumber, then tar-paper, and then matched flooring, this giving a draft proof arragement and one which is also vermin proof. Around the outside a two by four should be spiked and upon this the studding erected two feet apart. The walls are best constructed with rough stuff on either side of the studding, then a layer of tar-paper on either side, and the outside sheeted with drop siding, and the inside with matched flooring. These walls form dead air spaces, which add greatly to the warmth of the building. The building should be ceiled on the inside with matched lumber, the ceiling being nailed to the collar beams.

The roof should slope for the main part toward the south, the ridge coming four feet from the back. In constructing the roof, the boards should be laid close together with a layer of tar-paper under the shingles, which also adds greatly to the warmth.

The windows should be double sash of nine lights, each pane 10 10 by 12 inches, and they should be firmly screwed into place. Right in this connection, we would say that it is advisable to avoid too large a surface of glass as it presents a radiating surface, and should not exceed the area mentioned. Two windows should be placed in each pen, one foot apart and sixteen inches from the floor.

Log poultry houses are not at all desirable; they form veritable hives for lice, and many cracks and uneven surfaces make them difficult to whitewash properly. Again, unless kept constantly chincked they become very open, making it difficult to keep them warm. On the other hand properly constructed frame buildings are almost absolutely draught proof, while the tar-paper between the walls, and the ease with which they may be whitewashed makes them easily vermin proof.

The main poultry building at the Station is 72 feet long and 14 feet wide with a four foot passage in the rear. It is divided into pens 12 feet long and 10 feet wide, and is set upon a foundation of stone eighteen inches wide and two feet high. The slope of the roof is for the main portion to the south, the ridge coming just above the passage way four feet from the rear wall. This slope of roof is of great advantage since the sun rapidly melts the snow on the southern incline making it warmer and drier, while on the other side the slope is so steep that the snow does not lodge there.

The next most important feature is the double floor. The exit from the pens is through the floor into the space underneath the building. This basement has a ground floor, and it is two feet from the ground to the sills. In summer, this makes a fine, cool and shady place when doors shown in cut No. 3 are down and portholes open, while in winter with the doors raised the low sun enables the sunlight to extend more than half of the distance from front to rear, making an ideal place for dusting and scratching. This feature adds greatly to the usefulness of the building, since it so materially increases the floor space without affecting the area of the roof.

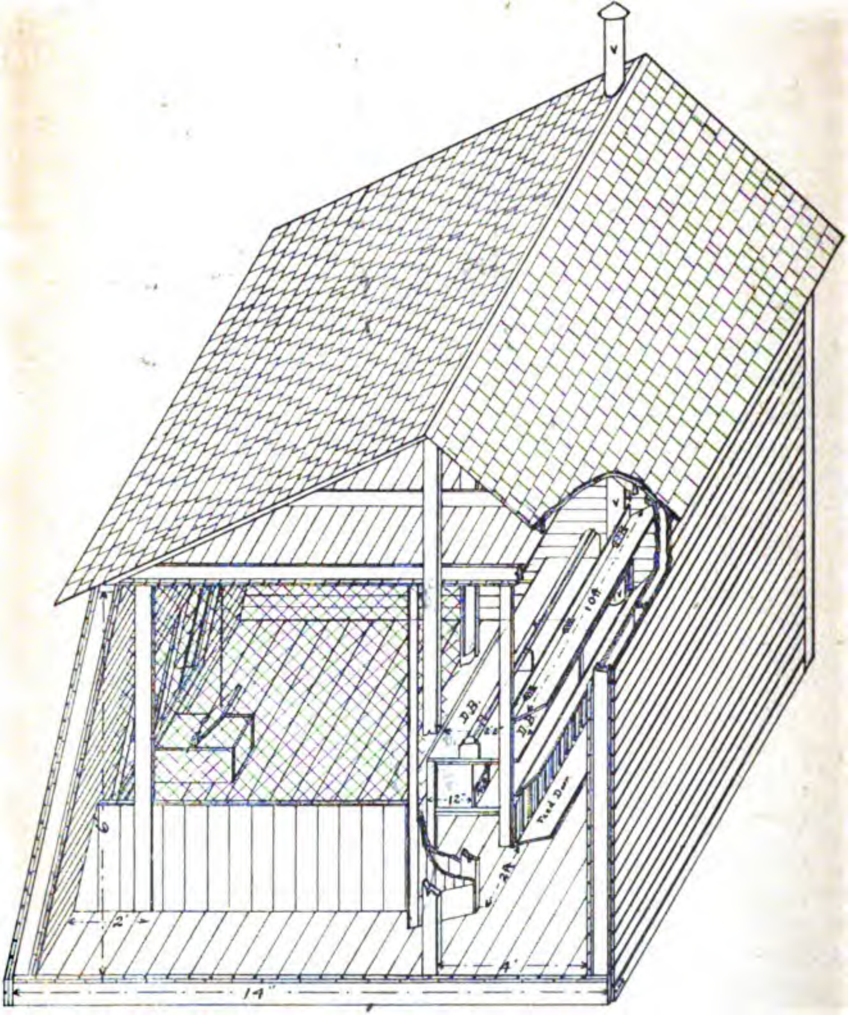


FIGURE 1.—POULTRY HOUSE.

The brooder house, 36 by 14 feet, is divided into seven pens, each 5 by 10 feet, and a passageway in the rear four feet wide. Doors two feet wide enter each pen. Pens are divided by two feet of matched flooring and netting above. This building has no basement but a ground floor of cinders. The height of the ridge is 10 feet, rear wall 5½ feet to top of studding, front wall the same. The front wall is inclined inward, making the top just two feet nearer the rear wall than the bottom. This is with a view to taking as great advantage of the sunlight as possible.

Construction: Every five feet cedar posts were set 2 feet 6 inches in the ground with about nine inches exposed above the surface of the ground for the walls. The posts were squared on two sides and 2 by 4's fourteen feet long were nailed to each pair of posts in the front and rear walls, dividing the floor into seven sections. Then a 2 by 6 was spiked on the top of the posts, this constituted the sill of the building; upon this the studding was erected. The partitions of the different pens were erected along the 14 foot 2 by 4's which were spiked to the posts. The building was covered with rough lumber, then with a layer of tar paper, and covered by drop siding. The roof was sheeted with boards close together, then tar-paper under the shingles. Old hot-bed sashes, 6 by 4 feet, were used as windows and were placed directly in the center of each pen. Cinders were used as a floor for the building and were tramped in when slightly moist. A board was nailed firmly around the outside to prevent them from falling out.

BUILDINGS.

Figure 1 illustrates a model form of poultry building, and is with the exception of some slight details of the same construction as our main building. This house is 14 feet wide, pens 12 feet long with walls, roof, floor and windows constructed as previously described. A four foot passage way runs tnroughout the rear. Access to the pens is through doors two feet wide, which open inward against a partition between the pens. This partition is matched stuff for 2 feet and then wire netting up ty the ceiling. The arrangements of the roosts (R], the drop-boards (D. B.,) the nest boxes (N. B.,) and the feed board are very simple. The fowls are fed their soft feed through the slatted front of the pen upon the hinged feed door, which when not in use is hooked in a perpendicular position. These slats are three inches apart and fourteen inches high. Immediately above upon a platform 20 inches wide, the nest boxes are placed facing the passageway. Eggs are gathered from them by opening the hinged door in the passageway which extends in front of the platform. Nests are best made of ½ inch lumber boxes 12x12x14 inches dimension. Above the nest boxes is another platform 22 inches wide which catches the droppings from the roosts. This drop board (D. B.) extends about 1½ inches into the passageway so that in cleaning the edge a pail may catch under it. The roosts are placed 6 inches above the drop boards and are 2x3½ inches with corners rounded off and the flat side up. (V.) Ventilator is placed in corner of pen close to the passageway, and damper is operated therefrom. The exit through the floor is surrounded by a box as shown. This is to prevent litter from falling through. The front wall is inclined inward two feet at the top in order to take greater advantage of the sunlight, and building is sealed with matched flooring upon the lower side of the collar beam. Where it is intended to keep only 40 or 50 birds, a saving of space may be effected by running the passageway through the center of the building from front to rear, making two pens and arranging nest boxes, etc., on either side of the passageway with the door on the north side and the ventilators in either end.

VENTILATION.

Proper ventilation is an important factor in the management of the poultry house, and the object should be to remove the foul air and retain the warmer and purer air without causing a draft. Our method of securing this result is simply this: An ordinary stove-pipe with damper extends from a hood on the roof to within six inches of the floor. The lighter and warmer air near the roof of the building warms the metal pipe which is a good conductor, which in turn warms the air inside causing it to rise slowly. As a result the air flows into the pipe from the opening near the floor, this gradually removes the air in the immediate vicinity of the fowl. We have found this method an admirable one in our practise, performing the work excellently.

BROOD COOPS.

Where chicks are raised in considerable numbers, either by hen or machine, it is very essential for the best results that they be removed from their mothers or foster mothers as soon as they require no further protection from cold than shelter, and colonized in small flocks far enough apart to keep them from mixing with other lots, and also far enough apart to give them a good range. Chicks are never healthier than where they can forage about, making about half their living on the insects and grubs which they find. In order to afford chicks this opportunity for foraging coops which are wind and rain proof and which are easily moved from place to place are necessary. The best coop for this purpose is one we use and here describe :

Bottom constructed of matched flooring 35 inches long laid on two pieces of two by four 50 inches long. Flooring should be laid on edge of two by four in order to raise floor from the ground. Floor should be exactly four feet long leaving the two by fours extending one inch at either end.

Top 4 feet 2 inches long, 41 inches wide, and is best covered with galvanized iron which is to be had in 90 inch lengths, cutting with very little waste, The box part is then made just large enough to fit over bottom and rest on projecting pieces of the two by four, it is two feet nine inches in front and two feet six inches behind. The ends of the box should be cut one inch shorter than the sides to give ventilation in the one inch strip it leaves at the top. A slide door, 8 by 8 inches, made of the scraps of galvanized iron should be cut in front in the center. Two windows, 9 by 10 inches, should be cut in either end two feet from the bottom and six inches from the front, the holes should be covered on the inside with wire gauze. Rabbeted strips should then be nailed on the outside, and lights 10 by 12 inches used as windows. This is an ideal coop for convenience. It can very readily be loaded upon a wheelbarrow and moved as often as desired. It is also very convenient for cleaning, since when the top is lifted off the bottom and the bottom tipped up when the coop is cleaned. No roosts should be used, plenty of dry earth on the bottom will keep the birds clean and the crooked breast bones will be avoided. A coop such as described should accommodate from twenty-five to thirty chicks.

BROODERS.

The brooder in use at the Station owes its design to James Rankin, South Easton, Massachusetts, and is undoubtedly one of the cheapest and most servicable indoor machines extant. Its construction is as follows : A box is made three feet square and of four pieces of eight inch lumber surfaced. Upon the top of this box, for a cover, is nailed

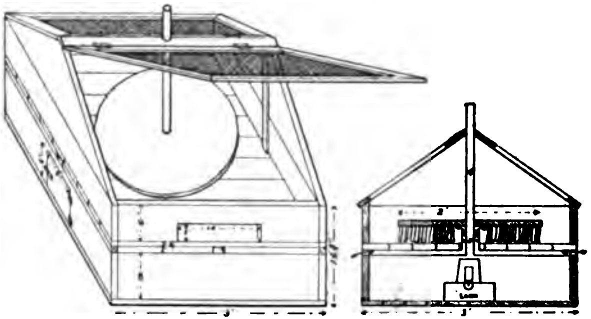


FIGURE 2.—BROODER.

a piece of zinc entirely covering the box. This zinc has a hole in the center over which is soldered a pipe 1½ inches in diameter and 22 inches long. This pipe is soldered on the outside, the metal being the top of the box. Next comes the floor over this zinc, but not touching it because an inch strip, 1 by 1, should be nailed on around the outside in order to make an air space between the floor and zinc. This strip should be broken; midway on either side an inch opening should be left for the admission of outside air to the space underneath the floor. The floor should be made of "ceiling" smooth surface up. Exactly in the center of this floor a hole should be cut 2½ inches in diameter and in this hole a pipe 2½ inches in diameter and 3 inches long fastened. This pipe should just extend throngh the floor level with the underside of the bottom. Through this pipe the long ventilating pipe will go. This completes the body part of the brooder and a hover and top complete the requirements. The hover should be made in the form of a circle two feet in diameter, in the center a hole large enough to allow the vent pipe to pass should be cut, and four legs three inches long tacked on to raise it to the required height; then tack a light fringe of jute sacking around the edge only. This is the hover complete. Next is the top. Make another box similar to bottom, using four pieces of six inch lumber dressed. Upon opposite sides a piece cut with a double pitch 3 feet long and 1 foot high in center should be nailed to form the ends and the apex and joined with a piece 34 inches long and 2½ inches wide cut with bevel to allow the screen doors, which should constitute the two sides of the roof, to fit snugly. This box portion should have a little door cut in it and an in-

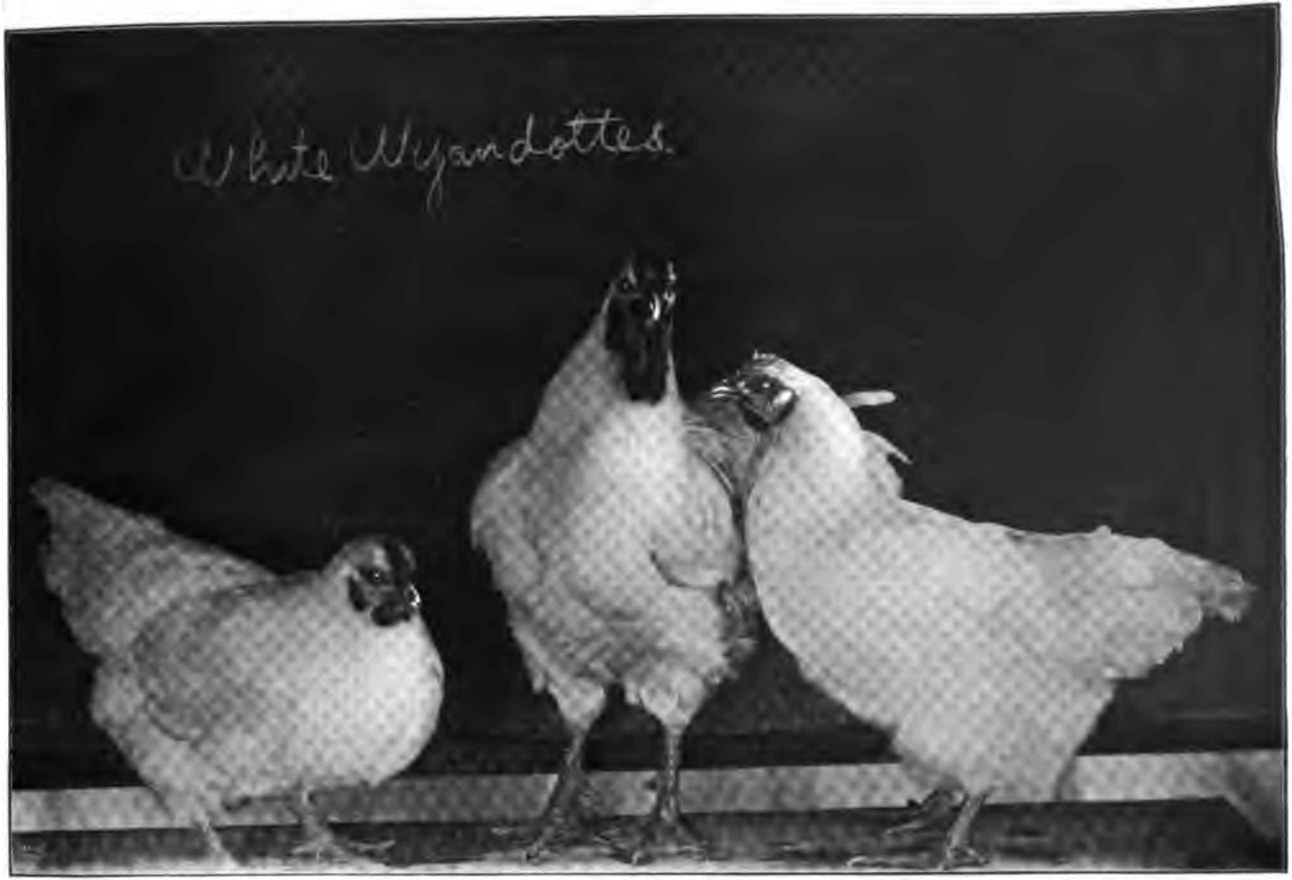


Fig. 2.- White Wyandottes
The property of the Station.

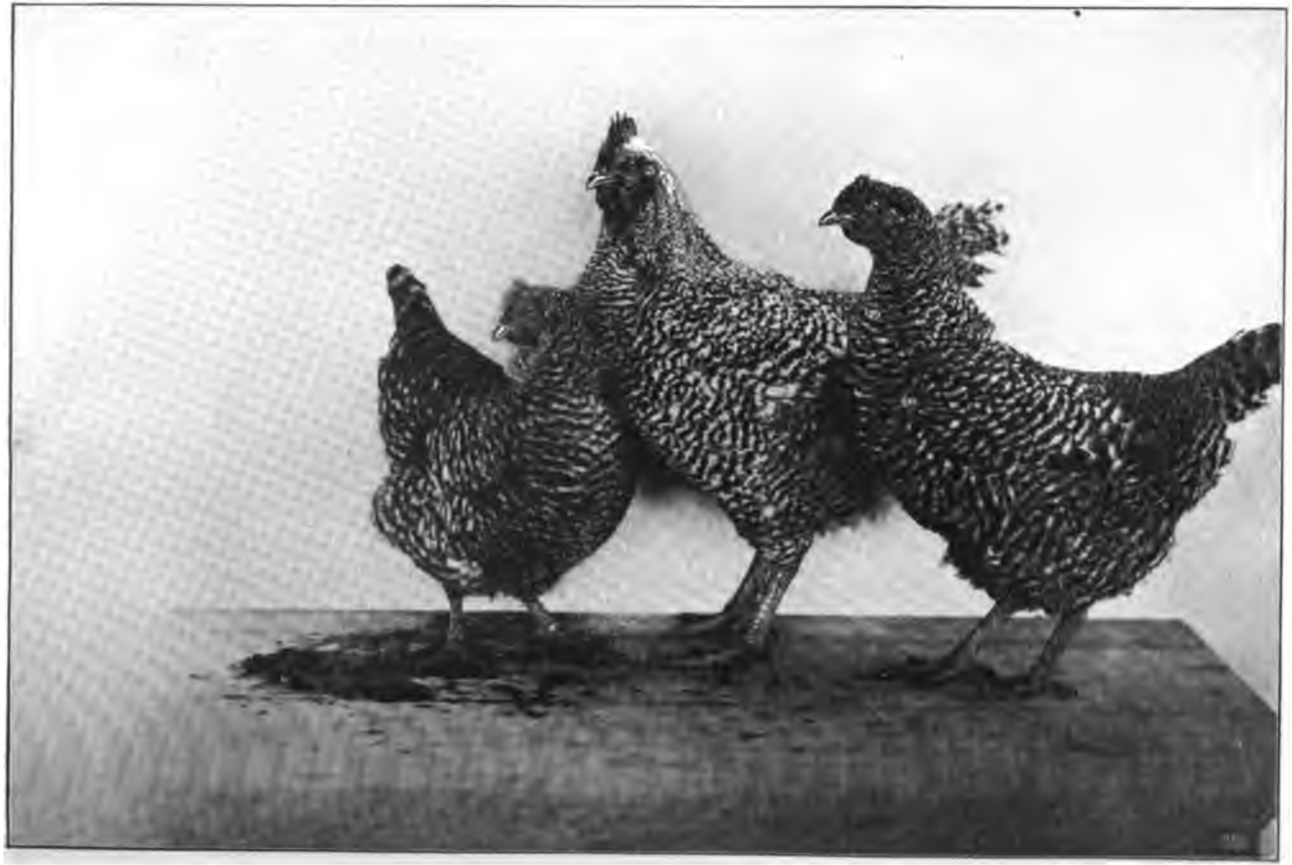


Fig. 1.- Barred Plymouth Rocks
The property of the Station.

cline made for chicks to run in and out of the brooder. The working of this brooder is extremely simple; a brooder stove is placed under the box and it heats the metal cover; this in turn heats the air in the space between it and the floor. This air on being warmed rises upward through the 2½ inch pipe and flows out over the chicks that are underneath the hover. Since this air comes through the holes between the 1 by 1 inch strips and does not come in contact with the lamp, a pure and constant supply of air is insured, giving almost perfect ventilation in addition. These brooders serve the purpose very well where only a limited number of chicks is to be raised, but where the business is to be conducted upon a larger scale either coal or wood heaters with pipe system is best.

INCUBATOR OILS.

One of the main causes of trouble with the lamp in incubator and brooder management is the poor oil. As a rule this may be overcome by cleaning the wick every day and keeping the burner cool by having the point of connection between burner and oil tank submerged in water. It is, however, of much greater advantage to use an oil which has been carefully distilled, and which does not contain these heavier oils which pass over only when, in the process of manufacture, the oil is heated beyond the temperature necessary to distil off the kerosene. Another difficulty is the low flashing point of many of the oils in use here, all of them below the standard. The flashing point of an oil is the point at which the temperature is sufficiently high to cause it to flash on the surface when a lighted splinter is applied. This marks the danger point, and since the tendency of any lamp which is kept constantly burning is to become heated around the burner the danger of heating the oil to its vaporizing point is considerable.

The oils sold in this state are notoriously inferior, none we have examined had a flashing point higher than 105 degrees F., and the cause of this is that the lighter oils, the napthas, etc., are contained as impurities in the kerosene. The trouble of smokiness, too and clogging of the wick results from presence of lubricating oils and parrafines which have been distilled over with the kerosene. With a view of determining which is the best oil for incubator purposes the writer, under the direction of Dr. Traphagen, tested the different oils on sale in Montana. None of them came up to the standard, and some were even dangerous to use owing to their extremely low flashing point. The results of these are given in the following table :

	Flashing point.	Burning point.
Elaine oil	104	136.8
Bulk Oil No. 1	100	136.0
Bulk Oil No. 2	100	136.0
Continental Safety	100	129.00

From this table it is shown thaf the brand "Elaine," although below the standard, comes nearest the mark, having the highest flashing point. It is, however, very free from the heavier oils and does not gum or crust the wick to any perceptible degree. The common "Bulk,' oil is absolutely dangerous and its sale is certainly a menace to public safety.

PRESERVING EGGS.

With a view of testing the relative value of lime and salt mixtures and water-glass as egg-preservatives, we pickled about 60 dozen eggs in two lots. The mixtures were :

No. 1—Lime, fresh, 3½ lbs., salt 4¾ lbs., water 8 gallons.

No. 2—Waterglass, 1 part water-glass to 18 parts water.

These eggs remained in the solutions for about six months. When examined the water-glass was found to be the best pickle, although the lime and salt served its purpose very well; still the whites of the eggs preserved in this mixture were much more watery thun the whites of those preserved in the water-glass. These were difficult to distinguish from fresh eggs since the white was quite firm and yolk stood up upon it just as though fresh. Another advantage in the water-glass is that it does not seem to affect the shell of the egg as the lime mixture. Eggs from the lime and salt mixture being much more liable to crack, either in cooking or handling. We consider this matter of preserving eggs of great importance in this state since prices are so high for eggs in the winter season. We do not for a moment advise the selling of preserved eggs for fresh laid, but we have no hesitancy in saying that when the market finds that these preserved eggs seem almost as good as the fresh eggs, it will certainly be willing to pay a price which will leave a good cash margin in favor of pickling. Water-glass or sodium silicate is a liquid of rather a smooth, slippery consistency, readily soluble in water. It may be obtained through any druggist at a cost of about 75 cents a gallon. In using it we would advise the use of stone jars or crocks. The water used should be quite pure and if not it must be boiled. Jar should be covered to exclude any dirt, and kept at the temperature of a cool cellar. Sometimes the specific gravity of the solution is greater than that of the eggs, in which case the tendency will be for them to float, when they may be forced down by a plate or similar arrangement with a weight on top.

EXPERIMENTAL WORK.

In March, April and May, 1900, we fed four pens of fowls, 16 in each, 15 hens and 1 cock, upon four different rations with a view of determining what effect a variety ration, (meat, vegetables and grain), a meat ration, (meat, meal and grain), a vegetable ration, (vegetables, meal and grain), and a straight grain ration had upon

(1) Egg production.
(2) The percentage of fertile eggs and dead germs.
(3) Value of eggs estimated upon protein and fat.

CONDITIONS OF EXPERIMENT.

The fowls were housed in a log building in pens 9 by 10 feet with yards 10 by 16 feet. The yards were very small as the ground in front of the building was being graded. The fowls obtained no vegetable food whatever from the yards, as they were covered with chaff and straw. Grit, burnt bone and dust baths were supplied the fowls alike, as was plenty of fresh water. The birds all remained quite healthy throughout the duration of the experiment, two months and a half, no loss or any disease occurring. Each pen contained 11 hens two years old and four pullets and one cock. The male birds were all vigorous yearling Plymouth Rock and well developed, so that a maximum mount of service could be expected from each of them. The hens vere about one-half scrub stock, Cochin, Game, Leghorn, and Rock nongrels, and the remainder pure breed Plymouth hens. They were s evenly divided in respect to variety as possible. Feeding was done hree times a day, about 7 a. m., again at 11:30 a. m. and from 4 to :30 p. m. In each pen the floor was covered with litter and the grain ed therein, so that, though closely confined, all had plenty of exercise.

RATIONS.

Pen No. 1 received in the morning 12 ounce feed, ¼ bran, ¼ oat chop, ¼ meat, ¼ vegetable, then a mangold was given, and at noon clover with a little meat or ground green bone. Evening feed was grain (wheat or oats).

Pen No. 2 received in the morning 12 ounce feed, ¼ bran, ¼ chop, ½ meat, later some grain, and at noon a little meat or bone. Evening feed was grain (wheat or oats).

Pen No. 3 received in the morning 12 ounce feed, ¼ bran, ¼ chop, ½ vegetable' then mangold and a little grain, and at noon clover and roots, and in evening grain (wheat or oats).

Pen No. 4 received in the morning 12 ounce feed of chop, ½ bran ½ oats mixed with water.

COST OF DIFFERENT RATIONS:

Pen No. 1—Cost of bran, oat chop, meat and bone, vegetable, grain, $1.97.

Pen No. 2—Cost of bran, oat chop, meat and bone, grain, $2.03.

Pen No. 3—Cost of bran, oat chop, vegetable, grain, $1.79.

Pen No. 4—Cost of bran, oat chop, grain, $1.95.

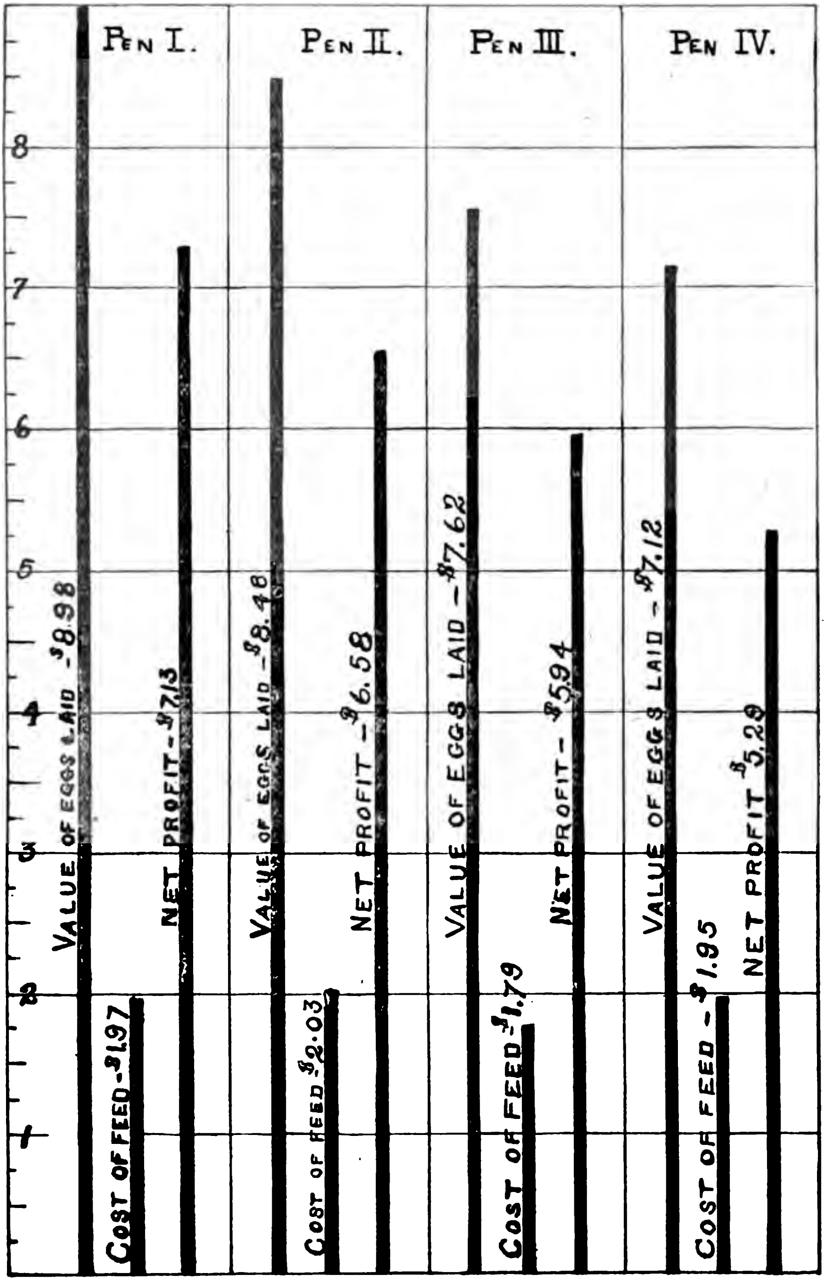
It was the endeavor in composing these different rations to show the advantage of a variety, and the variety of feeds used was such as could be made use of generally.

In the second ration we endeavored to show the value of a succulent vegetable feed by eliminating it.

In the third the value of meat and bone was demonstrated in the same manner.

In the fourth we endeavor to show the fallacy of feeding, as many do, a straight grain ration. And in the results it was shown, from egg production, that the greatest egg yield was received from the first, the variety ration, while the smallest returns came from the hens fed upon the grain alone. The advantage here must be very apparent, since the cost of both rations was almost the same. The following table shows briefly and concisely the egg yield from the different pens, the weigh of eggs, and their market value:

Pen.	No. Laid.	Weight.	Cost	Value.	Gain.
1	431	45-8 oz.	$1.97	$8.98	$7.14
2	407	44-4 oz.	2.03	8.48	6.58
3	366	39-11 oz.	1.79	7.62	5.94
4	342	36-6 oz.	1.95	7.12	5.29


PEN I.
PEN II.
PEN III.
PEN IV.
8
7
6
5
4
3
2
1
VALUE OF EGGS LAID - $8.98
NET PROFIT - $7.13
COST OF FEED - $1.97
VALUE OF EGGS LAID - $8.48
NET PROFIT - $6.58
COST OF FEED $2.03
VALUE OF EGGS LAID - $7.62
NET PROFIT - $5.94
COST OF FEED - $1.79
VALUE OF EGGS LAID - $7.12
NET PROFIT $5.29
COST OF FEED - $1.95

In computing the cost of feed in this experiment the following values were used :

	Per cwt.
Oat chop	$ .96
Bran	.70
Oats	.90
Wheat (frosted)	.40
Mangolds	.75
Clover	.30
Potatoes	.50
Beef and Bone	1.00

The eggs were valued at 25c a dozen.

The financial results of this experiment are excellent. It has been shown that even where fed upon grain alone and closely confined, considerable gain was made, while the pen receiving the greatest variety of feed, costing about the same, a further gain of $1.84 was made. The total returns from pen No. 1, deducting the cost of feed, being $7.13 and from pen No. 4 being $5.29. In the meat- and vegetable-fed pens the one receiving the meat and bone, though the more expensive ration, was still the more profitable, yielding a profit of 64 cents over pen No. 3, the total profits from the four pens of 60 birds being $24.94 or 41½c per bird for period of experiment—2½ months.

FERTILITY.

The influence of feed upon the percentage of fertile eggs and upon the vitality of the chick has been discussed to some considerable extent in the past three or four years, and it was with a view to finding just how much effect different rations had upon the fertility and the percentage of dead germs that we tested all the eggs laid in this experiment. We would have preferred to have carried the work further, incubating the eggs to the hatching stage, also raising the chicks, but our facilities would not permit running the eggs longer than eight days.

We found that the percentage of fertile eggs was the largest fro pen No. 4, the pen in which the fewest eggs were laid, and this rati continued throughout the four pens, the relation of the percentage o fertile eggs to the number laid, was an inverse ratio as the next larger percentage of fertile eggs was found in pen No. 3, the next in No. and the lowest in No. 1.

Now in the opinion of the writer this result should not deter any one from feeding breeding birds on a variety of feed. Although the percentage of fertile eggs is greatest in the pen receiving the grain feed, still the actual number of fertile eggs received from pen No. 4 was but very few more than from pen No. 1, pen No. 1 having 232 and pen No. 4, 239. It seems that this can be accounted for in this way chiefly: Fifteen hens laying the number of eggs that pen No. 4 did, just about reached the cock's limit of successful fecundation, and where a larger number of eggs was to be fertilized, the male bird was unable to meet the demand. I think, however, that had eight or ten hens been used the effect of the different rations upon the fertility could have been more correctly shown, but in the case of our experiment there were really more eggs requiring fertilization than the male bird was able to attend to, for we find that the number of fertile eggs from the different pens varies but slightly, and this variation might be owing to some difference in vigor of the cock.

The following were the number of fertile eggs from the different pens:

No. 1.	No. 2.	No. 3.	No. 4.
232	229	223	239

These results seem to indicate that the matter of the number of hens to the cock should be of extreme importance, since it seems evident from this experiment that about 425 eggs were all the male bird could fertilize in 2½ months, and as a result the conclusion should be that the male should receive a complement of hens which would lay from 180 to 190 eggs a month.

But still we do not wish to make the inference that were there fewer hens the relations would have been changed, for in that case it would follow that had the feeding any appreciable effect upon the vitality of the germs, there would be fewer dead germs in No. 1 than in Nos. 2, 3 and 4, in their decreasing ratio, but we found throughout that these conditions were reversed, No. 1 having the greater number of dead germs while No. 4 had the fewest. The following table will show the relative number of dead germs in the different pens:

No. 1.	No. 2.	No. 3.	No. 4.
106	93	73	52

Now these results would almost lead an observer to believe that a variety of feed is detrimental to the best fertilization, but we believe that this should not be the conclusion. Pen No. 4, receiving a more nitrogenous ration than No. 1, did not consume very heavy rations, since digestion and assimilation were not stimulated by succulent vegetable food or meat, and as a result the tendency was to firmer flesh and less fat than in the other pens. It is a well known fact among all breeders and stockmen that cattle, sheep or hogs which are overfat are difficult to get with calf, lamb, or in pig, as the case may be. We might consider that the more probable explanation is this: That the mixed rations would be much better assimilated than the sole grain ration, and as a result we would think it wise to make it a point to keep the breeding birds upon a little shorter rations than the laying stock, at the same time allowing them a variety of feed.

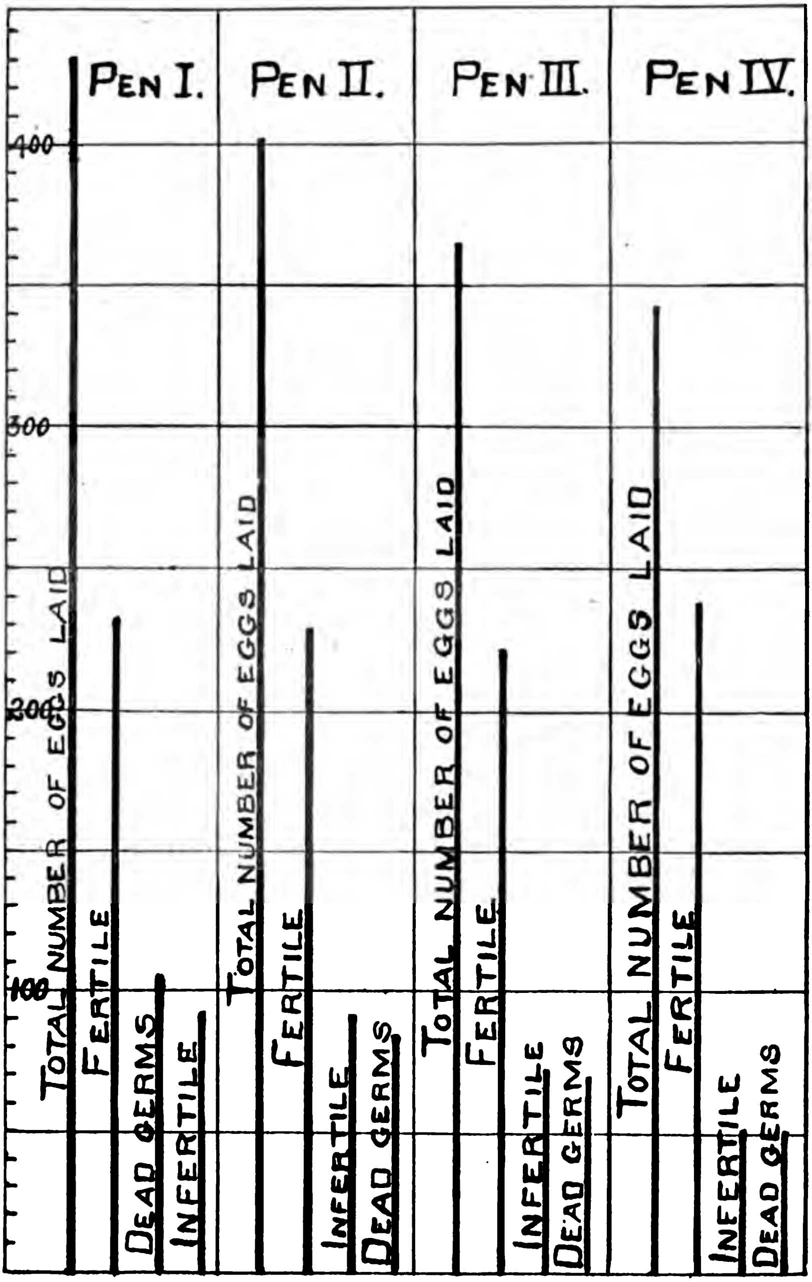
This problem deserves further careful investigating under somewhat different conditions and with fewer hens to the cock, that we may ascertain with more certainty the effects of the different rations upon egg fertility. Table No. 2 graphically illustrates the fertile, infertile and dead germs in the different pens.

EGG ANALYSIS.

The results of the analyses of the eggs from the different pens did not show any marked differences in the composition of the eggs. The results, however, lead us to believe that there is considerable individuality about the eggs from the different hens, as there is in the milk from different cows, and the work has been valuable herein, that it has pointed out such facts as will serve as guides in future work. There are however, some indications that go to show that the most highly nitrogenous rations tend toward a more nitrogenous production, for in Pen No. 1, we notice that the percentage is lower both in yolk and white than in eggs from Pen No. 4, as is here shown:

	Pen No. 1.	Pen No 4.
Per cent to Yolk,............	2.36	2.42
Per cent of Fat in Yolk......	31.63	30 46

It was noticed, however, throughout, that where fat ran high, the nitrogen ran low and vice versa. The percentage of nitrogen in dry yolk concur also with these results as do the percentage of fat in dry yolks. Pens 2 and 3, compare very closely with No. 4, the differences in composition being rather irregular owing chiefly to large variations of individual eggs.


PEN I.
PEN II.
PEN III.
PEN IV.
400
300
200
100
TOTAL NUMBER OF EGGS LAID
FERTILE
DEAD GERMS
INFERTILE
TOTAL NUMBER OF EGGS LAID
FERTILE
INFERTILE
DEAD GERMS
TOTAL NUMBER OF EGGS LAID
FERTILE
INFERTILE
DEAD GERMS
TOTAL NUMBER OF EGGS LAID
FERTILE
INFERTILE
DEAD GERMS

A rather interesting fact with regard to the percentage of shell in the large and small eggs, is that large eggs possess the greater percentage of white and yolk, while small eggs in turn run almost .75% in shell. The following table shows average percentage of shell, yolk and white of large and small eggs.

No. Eggs.	Ave. Weight.	Per cent Shell.	Per cent Yolk.	Per cent White.
8	57 91 gr.	10 47 gr.	34.57 gr.	54.92 gr.
8	41.86 gr.	11.12 gr.	34.44 gr.	54.16 gr.

There was, however, practically no difference in the average percentage compositions of these large and small eggs, as the following table will show :

	Nitrogen in Yolk Per cent.	Nitrogen in Dry Yolk Per cent.	Fat in Yolk Per cent.	Fat in Dry Yolk Per cent.	Nitrogen in White Per cent.	Nitrogen in Dry White Per cent
Large Eggs......	2.36	4 85	31.46	63 47	1 98	13.73
Small Eggs......	2.39	4.94	30.83	63 56	1 96	13.58

The following tables give the average composition of the eggs from the analyses of samples made April 1, May 1, May 15, 1900 :

PEN No. 1.

1900	Nitrogen Yolk Per Cent.	Nitrogen Dry Yolk Per cent.	Total Wt. of Nitrogen yolk Grams.	Fat in yolk Per cent.	Fat in Dry yolk Per cent.	Total fat Yolk Grams.
April 1,............	2 44	5 07	.376	31 54	64 45	4 94
May 1,....	2.18	4.52	.435	31 37	64.82	6.39
May 15...........	2.47	5.09	.339	32 00	65 84	4 38
Average........	2.36	4.89	.383	31.63	65.03	5 23

PEN No. 1.

1900	Nitrogen in white. Per cent.	Nitrogen in dry white. Per cent	Total wt Nitrogen in white, grams.	Total wt Nitrogen in Egg, grams.	Shell to Egg. Per cent.	Yolk to Egg Per cent.	White to Egg. Per cent.
April 1.........	2 07	13.39	.463	.840	10.77	36.60	50.05
May 1..........	1 87	....	....	...	.....	.....	.....
May 12.........	1 83	13 23	.493	.882	10 70	30.62	58.67
Average.....	1.92	13.41	.532	9 78	10.73	30.61	54.36

PEN No. 2.

1900	Nitrogen in Yolk Per cent.	Nitrogen in Dry Yolk Per cent.	Total weight of Nitrogen Yolk Grams	Fat in Yolk Per cent.	Fat in Dry Folk Per cent.	Total fat Yolk Grams.
April 1.....	2.41	4 88	.407	32.27	66.45	5 35
May 1...........	2.28	4 63	420	31.54	63 23	5 88
May 15...........	2.41	4 93	.380	32.31	65.66	5 02
Average	2.36	4 82	402	82.04	65.11	5.41

PEN No. 2.

1900	Nitrogen in white. Per cent.	Nitrogen in dry white. Per cent.	Total wt. Nitrogen in white, Grams.	Total wt. Nitrogen in Egg, Grams.	Shell to Egg Per cent.	Yolk to Egg Per cent.
April 1	2.19	14.02	.526	....	11.58	35.66
May 1	1 73	13 03	541	.961	11.36	33.01
May 15	1.80	13.18	.586	.967	10.39	31.26
Average	1.90	13.41	.451	.964	11.11	33.31

1900	Per cent White to Egg.
April 1......................	52 73
May 1......................	55.51
May 15.................. ...	58.33
Average.................	55.52

PEN No. 3.

1900	Nitrogen in Yolk Per cent.	Nitrogen in Dry Yolk Per cent.	Total weight of Nitrogen Yolk Grams.	Fat in Yolk Per cent.	Fat in Dry Yolk Per cent.	Total fat Yolk Grams.
April 1	2.39	4.93	.367	30.70	63.69	5.15
May 1	2.41	4.77	395	32.80	64.98	5.87
May 15	2.51	4.84	.403	33.13	63.68	5.54
Average	2.43	4.84	.388	32.24	64.11	5.85

PEN. No. 3.

1900	Nitrogen in white Per cent.	Nitrogen in dry white. Per cent.	Total wt. Nitrogen in white, Grams.	Total wt. Nitrogen in Egg, Grams.	Shell to Egg Per cent.	Yolk to Egg Per cent.
April 1	2.11	13.77	.530	.876	11.79	35.55
May 1	1.85	13.68	.517	.913	10.49	33.09
May 15	1.30	10.25	.377	.778	10.27	31.71
Average	1.75	12.56	.474	.855	18.85	33.45

1900	Per cent white to Egg.
April 1	52.91
May 1	56.40
May 15	57.95
Average	55.75

PEN No. 4.

1900	Nitrogen in white Per cent.	Nitrogen in Dry Yolk. Per cent.	Total weight of Nitrogen Yolk Grams.	Fat in Yolk. Per cent.	Fat in Dry Yolk. Per cent.	Total fat Yolk. Per cent.
April 1	2.33	5.23	.454	29.93	61.49	5.61
May 1	2.57	5.07	.481	31.27	62.86	5.34
May 15	2.46	4.99	.329	30.20	62.24	4.11
Average	2.42	4.09	.421	30.46	62.46	5.02

PEN No. 4.

1900	Nitrogen in white Per cent.	Nitrogen in dry white. Per cent.	Total wt Nitrogen in white, Grams.	Total wt. Nitrogen in Egg, Grams.	Shell to Egg Per cent.	Yolk to Egg Per cent.
April 1	2.23	13.50	.579	10.84	11.07	36.54
May 1	2.07	13.60	670	11.51	9.67	31.95
May 15	1.80	13.73	.405	.725	10.88	33.30
Average	2.03	13.64	.531	973	10.47	33.93

1900	Per cent white to Egg.
April 1	53.27
May 1	58.46
May 15	55.80
Average	55.81

SUMMARY

The following are a few conclusions based upon careful consideration of work above detailed:

(1). Variety rations give best results in feeding for eggs.

(2). That poultry feeding is very profitable under present market conditions in Montana.

(3). That special care should be given to number of hens placed with cock in securing best results from breeding birds.

(4). That feeding breeding birds should be carefully studied with special care not to over-feed.

(5). That percentage of fertility and strength of germ depend to a considerable extent upon conditions and feed of breeding birds.

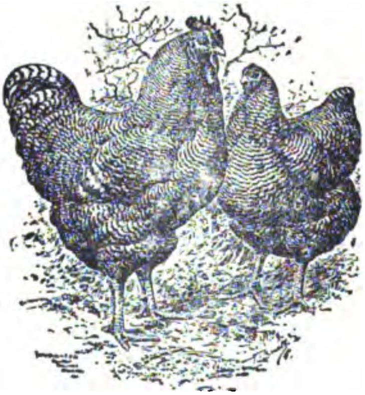
ACKNOWLEDGEMENTS.

To Dr. Traphagen, who has made the analysis of the eggs, and upon whose hands by far the major portion of the work fell, and who also supervised the testing of incubator oils, the writer tenders his thanks, and appreciation of this co-operation.

To Professor Gill for his excellent diagrams and drawings of poultry building, I express my indebtedness.

To Professor Brewer I wish to acknowledge the assistance rendered in revising the MSS. for this bulletin.

Henry C. Gardiner.



630.679
M9eb

BULLETIN NO. 27.

UNIV. OF [illegible]
FEB 18 19

MONTANA
AGRICULTURAL
EXPERIMENT STATION
-- OF --
THE MONTANA COLLEGE OF AGRICULTURE.

LIVE STOCK FEEDING TESTS
BEEF CATTLE, LAMBS AND SWINE.

(1) **Fattening Steers of different types on Clover, with and without Grain.**
(2) **Fattening Lambs on Clover, with and without Grain.**
(3) **Feeding Pigs on Grain alone, Grain and Sugar Beets, and Grain and Alfalfa.**

BOZEMAN, MONTANA, APRIL, 1900.

BOZEMAN CHRONICLE,
Bozeman, Montana,
1900.

MONTANA AGRICULTURAL

EXPERIMENT STATION.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman
Peter Koch, Secretary and Treasurer	Bozeman
George Kinkel, Jr., Vice-President	Manhattan
Walter S. Hartman	Bozeman
John M. Robinson	Bozeman

EXPERIMENT STATION STAFF.

S. M. Emery	Director and Horticulturist
F. W. Traphagen, Ph. D., F. C. S.	Chemist
Robt. S. Shaw, B. S. A.	Agriculturist
J. W. Blankinship, Ph. D	Botanist
R. A. Cooley, B. Sc.	Entomologist
Samuel Fortier, Ma. E.	Irrigation Engineer

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director,

Montana Experiment Station,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Experiment Station.

Bulletin No. 27. - - - April, 1900.

STEER FEEDING.

PART I.

The following report contains the results of experiments, relating to beef production, as conducted by the Montana Experiment Station during the winter season of 1900.

The objects sought were, viz:

First.—To determine whether our farm products could be profitably used in finishing range steers for market.

Second.—To determine to what extent it would be profitable to use grain along with clover in the fattening ration.

Third.—To compare the relative values of typical beef animals, as meat producers, with those conforming to the dairy type.

These three features were considered important, because of the fact that little feeding has as yet been done in Montana, except in a few instances where native hays have been used to a small extent. With the ever increasing area of clover and alfalfa, some attention must be given to the most economic disposal of these. The use of grain for fattening beef cattle is also an important factor. It is generally supposed that good beef cannot be made without it. That it is too costly to use in Montana and that larger quantities are actually required than are absolutely necessary. Then the question of quality in beef animals affects largely the return from food fed, and for this reason, some which did not conform to the beef type were used.

ANIMALS USED.

Sixteen steers were purchased on January 9, 1900, from Mr. V. C. Cline, of Bozeman. They were a mixed lot, showing Shorthorn, Hereford, Angus, Jersey and Holstein blood. In order to get comparative results, determined by the quality of the animals, two lots were selected as follows: Lot 2 consisted of six steers, of good beef type, showing only Shorthorn and Hereford blood. These went on feed January 15, with an average weight of 1,300 pounds. They were blocky, compact, smooth, medium boned animals, standing on fairly short legs and carrying a good deal of natural flesh (not fat). Lot 3, the opposite extreme of lot 2 in type, consisted of five steers, three of which showed a mixture of Jersey and native blood, and one a mixture of Jersey and Angus, and the fifth showing strong Holstein markings, but with a large blocky frame, well covered with flesh. Four of the steers in lot 3 showed more dairy than beef type. They were leggy and angular at all the points, chest, shoulders, back and rumps, and were light and open in the quarter and slack in heart girth. Lots 2 and 3 were fed on exactly the same foods, and in such quantity as they could use readily. Lot 1 consisted of five steers of only medium quality, viz: those remaining after the six best and five poorest had been picked. They were Shorthorn and Angus grades, showing only a slight infusion of the blood of these two breeds. While lots 2 and 3 were fed both grain and barley, lot 1 received clover hay only.

FEEDING.

These three lots were fed in yards, with sheds for protection from storm, consisting of poles covered with straw. Though these structures presented an uncouth appearance, they served a good purpose, providing ample protection, and as the results show, the steers made satisfactory gains under these conditions of freedom, where closer confinement might have been detrimental to the progress of range cattle on feed. While barns and sheds constructed of lumber are desirable in many ways, still, where it is not possible to provide these, the comparatively inexpensive straw sheds will answer well for a time. Food, both grain and hay, was supplied twice each day, being weighed out in every case. The hay in all three cases throughout the experiment consisted of first-class clover. The barley given to lots 2 and 3 was ground and fed morning and night. It was noticed that some care is necessary in starting steers on ground barley that have been unused to it. In some cases a liking for it is not developed readily at first; this allows others to receive too much and they too become sickened. Cases of this kind have occurred at the beginning, which proved unsatisfactory throughout. We have found it a good plan to start range steers on a pound of meal, at each feed, well seasoned with salt, and increasing a pound a day until seven or eight pounds per head per day is reached. This plan was adopted in the experiment with good success. The steers all went on feed in good form.

FOOD CONSUMED.

Lot 1, 5 steers, clover consumed from Jan. 16, to Mar. 28	12,550 lbs.
Lot 1, clover consumed, per head, per day	35.3 lbs.
Lot 2, 6 steers, clover consumed from Jan. 16 to Mar. 28	10,862 lbs.
Lot 2, 6 steers, barley consumed from Jan. 16, to Mar. 28	3,378 lbs.
Lot 2, 6 steers, clover consumed, per head, per day	25.5 lbs.
Lot 2, 6 steers, barley consumed, per head, per day	7.9 lbs.
Lot 3, 5 steers, clover consumed from Jan. 16, to Mar. 28	7,696 lbs.
Lot 3, 5 steers, barley consumed from Jan. 16, to Mar. 28	3,067 lbs.
Lot 3, 5 steers, clover consumed, per head, per day	21.6 lbs.
Lot 3, 5 steers, barley consumed, per head, per day	8.6 lbs.

In the data given above it will be noticed that the steers in lot 1 consumed a greater amount of food per day, than the other two, though they were the lightest bunch of the three, starting with an average of 1,162 pounds. Their food, however, consisted of clover alone. The figures also show that while lot 2, consisting of the good grade of steers, consumed a total of 33.4 pounds of food per day, lot 3, containing the poorer grade, used 30.2 pounds, though much lighter steers. Lot 2 began the experiment at an average weight of 1,300 pounds, and lot 3 at 1,196. Thus, while the food consumed by lots 2 and 3 was almost similar in amount, the difference in actual live weight and pounds of increase produced forms a striking contrast.

GAIN MADE DURING EXPERIMENT.

No. Lot.	W't Jan. 15, 1900.	W't Mar. 28, 1900.	Total gain.	Av. gain per head in 71 days.	Gain per head per day.
1, 5 steers on clover.	5,810 lbs.	6,425 lbs.	615 lbs.	123 lbs.	1.73 lbs.
2, 6 good steers on barley and clover.	7,800 lbs.	8,890 lbs.	1,090 lbs.	181.6 lbs.	2.55 lbs.
3, 5 poor steers on barley and clover.	5,980 lbs.	6,725 lbs.	745 lbs.	149 lbs.	2.1 lbs.

As shown in the table given above, lot 1, receiving clover hay only, made a total increase of 123 pounds each in 71 days, averaging 1.73 pounds per head per day. Lot 2, consisting of the best grade of steers, during the same period made a gain of 181.6 pounds, giving a daily increase of 2.55 pounds; while lot 3, composed of the poor grade of steers, on same feed as lot 2, gave an increase of only 149 pounds, or a daily gain of 2.1 pounds per day. These statistics indicate clearly that clover alone when fed to steers will give a reasonably good gain, which can be produced also with profit, though the quality of meat produced will not be equal to that from the grain-fed ones. We desire to call attention here to the much greater gain made by steers of the beef type, viz: 2.55 pounds per day as compared with the daily gain of 2 pounds by those of a poorer type on exactly the same feed.

COST OF FEEDING 71 DAYS.

Lot 1:

5 steers consumed 12,550 lbs. clover @ $6.00 per ton	$37.65
Total cost	$37.65

Lot 2:

6 steers (beef type) consumed 10,862 lbs. clover @ $6.00 per ton	$32.58
6 steers (beef type) consumed 3,378 lbs. barley @ 60c per cwt	20.26
Total cost	$52.84

Lot 3:

5 steers (poor style) consumed 7,696 lbs. clover @ $6.00 per ton	$23.08
5 steers (poor style) consumed 3,067 lbs, barley @ 60c per cwt	18.40
Total cost	$41.48

With the cost of foods for each lot and gains given a comparison of the relative cost of production is made as follows:

Lot 1, Total increase 615 lbs., cost of food $37.65, cost per cwt., increase....$6.12
Lot 2, Total increase 1,090 lbs., cost of food $52.84, cost per cwt., increase... 4.84
Lot 3, Total increase 745 lbs., cost of food $41.48, cost per cwt., increase.... 5.56

The best type of steers, therefore, not only made the greatest gains, but made them the most cheaply, producing 100 pounds gain at a cost of 72 cents less than the poorer type on exactly the same food. The poorer type had also the advantage of receiving slightly more grain per head throughout the experiment. Lot 3 received an average of seven-tenths of a pound more barley than lot 2. As lot 1, fed on clover only, were not first-class steers, we consider the results from them much below what they would have been with steers of the beef type.

RELATIVE PROFITS FROM THE THREE LOTS.

Lot 1:

Jan. 15, 1900, To 5 steers, weight 5,810 lbs. @ $3.47 per cwt........	$201.67	
Mar. 28, 1900, To 12,550 lbs. clover hay @ $6.00 per ton...........	37.65	
Mar. 28, 1900, By 5 steers, shrunk weight 6,120 lbs. @ $4.25 per cwt.		$260.10
Mar. 28, 1900, To net profit..	20.78	
	$260.10	$260.10

Lot 2:

Jan. 15, 1900, To 6 steers, weight 7,800 lbs. @ 3.47 per cwt.	$270.66	
Mar. 28, 1900, To 10,862 lbs. clover @ $6.00 per ton................	32.58	
Mar. 28, 1900, To 3,378 lbs. barley @ 60 per cwt...................	20.26	
Mar. 28, 1900, By 6 steers, shrunk weight 8,405 lbs. @ 4.25 per cwt.		$357.21
Mar. 28, 1900, To net profit....................	33.71	
	$357.21	$357.21

Lot 3:

Jan. 15, 1900, To 5 steers, weight 5,980 lbs. @ $3.47 per cwt........	$207.50	
Mar. 28, 1900, To 7,696 lbs. clover @ $6.00 per ton.................	23.08	
Mar. 28, 1900, To 3,067 lbs. barley @ 60 per cwt...................	18.40	
Mar. 28, 1900, By 5 steers, shrunk weight 6,410 lbs. @ $4.25 per cwt.		$272.42
Mar 28, 1900, To net profit	23.44	
	$272.42	$272.42

Lot 3, Average net profit per head at end of 71 days...... ....$4.15
Lot 2, Average net grofit per head at end of 71 days........................ 5.61
Lot 3, Average net profit per head at end of 71 days.................... ... 4.68

These figures speak for themselves. While clover alone gave a satisfactory return, better results were obtained where some grain was used, and the good class of steers gave a greater profit per capita by 93 cents each, over the poorer type.

As these steers were purchased, by the head, at a cost of $42.50, the price per cwt., $4.37, was determined from the total number of pounds weight and the total cost. This was necessary in order to fix a relative value on each of the three lots. At the time of disposal the selling price was 4¼ cents per pound live weight, under certain conditions of shrinkage. These conditions were eighteen hours away from food and drink before weighing, and the weights given in the financial statement are those designated as shrunk weights. These were not, however, used in determining the actual gain, which was derived from weights taken at the beginning and close of experiment under precisely the same conditions. Making an average of the three lots the total shrinkage amounted to 4.9 per cent. of total weight, when on full feed. While the relative profits given show an advantage in favor of lot 2, these would have been even still greater had each lot been sold at a figure corresponding to its quality. A valuation was made by an expert buyer, from the standpoint of quality and finish. While the bunch sold for 4¼ cents per pound, lot 1, finished on clover alone, was valued at 4¼ cents, lot 2 of the beef style at 4¾ cents, and lot 3 of the poor form at 4 cents.

PROPER TYPE.

We regret that cuts cannot be furnished illustrating the differences in type which have produced such marked results. The question is a very important one to the feeder, not only from a standpoint of relative gains and cost in production, but more important still, from a standpoint of quality in the finished product. The leading markets of today demand a compact, smooth, thick-fleshed product. Animals possessing these requirements can only be obtained from the purely beef types, such as the Shorthorn, Hereford, Angus, etc. Those in our lots showing Shorthorn and Hereford blood presented the most correct type, a very marked contrast to those possessing Holstein and Jersey blood. The best results can only be obtained from an animal possessed of compact form, as shown in a straight, broad, even, well fleshed back; chest broad, deep and full; shoulders broad on top; heart girth good, and crops full; hind quarters wide, deep and full. Such a form will carry a large quantity of flesh of good quality, while the more angular types, with narrow bodies, sharp chests, pointed withers and open thighs carry much less natural flesh and put on a poorer quality of increase. The purely beef types carry more natural flesh to begin with, and on the block show thick evenly fleshed carcasses. The types having an infusion of dairy blood showed a larger percentage of waste, and the fat was put on separately rather than being intermixed with the lean, In some cases also the meat was coarser grained and of poorer quality.

CONCLUSIONS.

1. That in our Montana valleys, where clover or alfalfa can be grown, these crops can be profitably used in the production of beef in a finished form. And the quality of these foods is such, owing to favorable conditions for the curing and storing of the hays, that only a comparatively small amount of grain is needed along with them to secure the best results.

2. That barley can be profitably used in conjunction with clover and alfalfa under our state conditions. That only small quantities of grain are necessary to give maximum results. The quantity need not exceed three-quarters of a pound of grain per day for each hundred pounds of live weight. Any excess above this amount will not give a proportionately greater gain and will materially increase the cost of production. The small proportion of grain will aid in giving an economic gain of the most desirable quality.

3. That in selecting steers to feed it is essential that only those of the beef type be used. Those of the beef type used made a gain of 2.55 tbs. per head per day, where the poor tpye made only 1.73 tbs. in the same time, with practically the same amount of food. And let it also be remembered that the increase made and original weight of best type was so improved during feeding as to be worth ¾ of a cent more per pound live weight at time of sale. And in addition to the question of greater gain comes that of cost of production even more important. While those of proper

type produced 100 lbs. increase at a cost of $4.84 per cwt., the cost of the same increase where the Jersey blood was present was raised to $5.56 per cwt. We wish to impress this fact as strongly as possible. Thousands of untypical steers are fed at a loss, at the same time making results which deceive the eye. The average feeder is not equipped so as to know exactly what returns he gets from feeding this poor class of animals. We cannot say too much in denunciation of them.

4. The results obtained indicate that we need not wait for improved conditions of sheds or stables, but can obtain satisfactory results from such improvised shelters as straw sheds. Our winter conditions are such as to permit the use of these in the absence of something better. Range cattle also, accustomed to a limitless freedom, will give better results when fed in dry, clean yards, with shelter in time of storm, than when subjected to closer confinement.

5. In selecting steers to feed it is urged that the lots be chosen with a view to uniformity in size, age and type. Attention should also be given to numbers, feeding even car load lots in every case. Then it will be possible to place prime finished beef on eastern markets in the springtime. With our unsurpassed conditions for growing alfalfa in many places, and clover particularly in the Gallatin valley, cattle feeding will furnish a means whereby these products can be disposed of to good advantage.

SHEEP FEEDING.

PART II.

During the season of 1898-99, comparative tests were made to determine the relative values of alsike, red clover and alfalfa, these three being the chief fattening foods of Montana. These can all be grown in large quantities, though some localities are more favorable to one than another; frequently two of them and occasionally all three can be grown in the same locality. In making these determinations, data was also secured relative to the cost of production of mutton, using the average range lamb.

In 1899-1900, tests were also conducted for the purpose of obtaining information relative to the advisability of using grains along with clover in preparing lambs for the market, and secondly to compare the returns obtained from lambs of the mutton type with those bearing more of a resemblance to the wool type. Because of the high price of grain, and especially oats, the impression prevails that it is not profitable to feed these along with good clover or alfalfa hay, and where feeding is carried on extensively it is certainly out of the question. In order to secure definite data one of the three lots of lambs was fattened on clover alone, throughout a period of ninety days. Then, in order to secure data relating to the profitable use of damaged grains, a second lot of lambs were fed during the same period on clover and damaged wheat. In the third instance, clover and oats were used under the same conditions.

The conditions governing the test were as follows: Sixty lambs were used in the experiment. These were Shropshire grades, all showing more or less dark color on face and legs. They were bred by Mr. Roy Martin, of Bozeman, and were purchased from him by the Experiment Station. They had been lambed early, during March and April, and were an exceptionally good bunch. These lambs when purchased, averaged 75 pounds in weight, and were bought for $3.00 per head.

Some time before going on experiment they were allowed to range the Station farm, getting what they could from stubble fields and clover pastures, from which two crops had already been removed. During this period, the lambs were not only maintained on what would have been otherwise wasted, but made a gain of 3¼ pounds each, raising the average to 78¼ pounds. A much greater gain could have been secured had these lambs been fed on the fields earlier, as soon as the crop had been removed, for some of the stubble on the farm had already been turned under and the third start of clover was injured by hard frosts. Some days before the experiment proper began, the lambs were divided and started on the basis of the plan to be followed. The experiment proper began on December 12. Feeding was delayed to this late date because of the fact that the lambs were able to secure food upon the fields until late, and it was the intention to dispose of them on a local market instead of by shipping. Sixty lambs in all were used, divided as evenly by weight and quality as was possible.

SURROUNDINGS.

The lambs were fed in open yards with shed room for shelter. Food was supplied in racks such as might be used on any ordinary ranch. As water was not accessible in the pens, the lambs were turned out to a little stream once each day. We believe, from observation, that much better results can be obtained by allowing free access to water.

FOODS USED.

Medium red clover, of average quality, was fed to all three lots alike, in such quantity as they could consume without waste. The wheat fed to lot 1, consisted of immature grain which had been frozen and afterwards heated in the bin. It was the same as that used in swine test. The oats, throughout the whole period, consisted of a No. 1 article with good market value. Lots 1 and 3 also received a small quantity of roots each.

FOODS CONSUMED BY EACH LOT.

TABLE NO. 1.

Dec. 12, 1899 to Mar. 12. 1900.	Clover pounds.	Grain pounds.	Roots pounds.
Lot No. 1	3,836	1,684 wheat.	769
Lot No. 2	5,738		
Lot No. 3	3,878	1,684 oats.	769

In this table it will be noticed that lots 1 and 3, receiving exactly the same amount of grain and roots, consumed nearly nineteen hundred-weight less clover than lot No. 2 without any grain.

COST OF FOODS.

TABLE NO. 2. LOT NO. 1.

Clover consumed, 3,836 ℔s. at $6.00 per ton	$11.50
Wheat consumed, 1,684 ℔s. at 40c per cwt	6.73
Roots consumed, 769 ℔s. at 15c per cwt	1.15
Total cost	$19 38

LOT NO. 2.

Clover consumed, 5,738 ℔s. at $6.00 per ton	$17.21
Total cost	$17.21

LOT NO. 3.

Clover consumed, 3,878 ℔s. at $6.00 per ton	$11.63
Oats consumed, 1,684 ℔s. at 90c per cwt	15.15
Roots consumed, 769 ℔s. at 15c per cwt	1.15
Total cost	$27.93

In making a comparison of the relative cost of the food used by the three lots, as given in the table No. 2, a striking difference is found in comparing lots 1 and 2 with 3.

Though lot 2 did not receive either grain or roots, they consumed 1,902 pounds more clover than lot 1, which nearly balanced the cost of grain received by lot 1. The total difference being a cost of $2.17 greater in the case of the former. The roots, of course, account for $1.15 of this difference. Had the same amount of roots been supplied to lot 2, the cost of production per pound gain would have been about equal to lot 1, the gain of 2 being increased and the amount of clover per pound gain decreased. Roots were not used for the reason that it was desirable to determine what the clover alone would do. Lots 1 and 3 provide statistics for an instructive comparison. The amount of clover, grain and roots being practically the same, and yet the food for lot 3 cost $8.55 more than for lot 1, under exactly the same conditions, except that wheat is used in one case and oats in the other. But while the lot receiving oats gave a greater gain, this did not counterbalance the big increase in cost caused by the oats, 1,684 pounds of wheat at 40 cents per hundredweight, costing $6.75, while the same amount of oats at 90 cents per hundredweight cost more than double that amount, viz: $15.15. It may be said of the roots that through their influence the total amount of dry matter per pound gain was reduced. The 769 pounds of turnips furnished only about 60 pounds dry matter in each case.

GAINS

Made by Each Lot of Twenty Lambs During a Period of Ninety Days.

TABLE No. 3.

Lot.	Wt. of 20, Dec. 12, 1899.	Av. wt., Dec. 12, 1899.	Weight Mar. 12, 1900.	Av. wt. Mar. 12, 1900.	Total increase.	Av. total gain.	Gain per head	
							per mo.	per day
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1.	1,535	76.75	2,136	106.8	601	30.05	10	.32
2.	1,580	79	2,066	103.3	486	24.3	8.1	.27
3.	1,565	78.25	2,200	110	635	31.75	10.58	.35

The most noteworthy feature with regard to the progress made by the lambs in this experiment consisted in the noticeable fluctuations caused by change of climatic conditions. From December 12, 1899, to January 2, 1900, good gains were made. The weather was moderately cold and steady. From January 2d to the 30th unusually warm weather prevailed, with showers or snow, followed by bright warm days. During this period the gains were greatly reduced. Then during the remainder of the feeding period, extending to March 12, a cold dry weather prevailed, and the most satisfactory returns were obtained. Not only were the returns from the food consumed decreased, but a smaller amount was eaten. Damp soggy fleeces and warm weather proved to be unsuitable conditions. This was noticed in a marked degree among the steers in an adjacent feed lot. The most satisfactory results were obtained with a steady, dry, cold, when no thawing occurred during the day.

COST OF PRODUCTION.

Cost per pound increase, lot 1 (clover and wheat)	$3.22
Cost per pound increase, lot 2 (clover only)	3.54
Cost per pound increase, lot 3 (clover and oats)	4.39

FINANCIAL STATEMENT.

For the purpose of bringing out clearly the relative value of the foods used, the weight value of lambs at commencement of experiment, cost of feeding throughout the ninety days, and actual market values are each given separately. The lambs were purchased some time before the experiment began, and were allowed to glean from meadows, stubble fields and along lanes and fences, utilizing material from which there would otherwise have been no return. During this period of less than one month the lambs not only maintained themselves, but made an actual gain of three pounds each, raising the average weight from seventy-five pounds at time of purchase to seventy-eight and a fraction at time experiment began. The price paid for the lambs being $3.00 per head, and the average weight being 75 pounds, the cost price per pound was 4 cents. Upon this basis the value of each lot of lambs starting on feed December 12, 1899, is estimated, according to live weight.

ABSOLUTE RELATIVE PROFITS FROM LOTS 1, 2, AND 3.

TABLE 4.

Lot 1, To 20 lambs, weight Dec. 20, 1899, 1,535 lbs. at 4c.	$ 61.40	
Lot 1, To clover, wheat and sugar beets	19.38	
Lot 1, By 20 lambs, weight Mar. 12, 1900, 2,136 lbs at $4.68.		$100.10
Lot 1, To net profit	19.32	
	$100.10	$100.10
Lot 2, To 20 lambs, weight Dec. 12, 1899, 1,580 lbs. at 4c.	$ 63.20	
Lot 2, To clover hay	17.21	
Lot 2, By 20 lambs, weight Mar. 12, 1900, 2,066 lbs. at $4.68.		$96.81
Lot 2, To net profit	16.40	
	$96.81	$96.81

Lot 3, To 20 lambs, weight Dec. 12, 1899, 1,565 ℔s. at 4c.	$ 62.60	
Lot 3, To clover, oats and sugar beets	27.93	
Lot 3, By 20 lambs, weight Mar. 12, 1900, 2,200 ℔s. at $4.68.		$103.09
Lot 3, To net profit	12.56	
	$103.09	$103.09

Net profit per head, lot 1, after 90 days feeding period	96c
Net profit per head, lot 2, after 90 days feeding period	82c
Net profit per head, lot 3, after 90 days feeding period	62c
Average net profit per head for the three lots	80c

While the relative profits are given, in the above tables, from the results at the close of the experiment it is only fair to state that 58 lambs went to market instead of 60. There were two losses from time of close of experiment, to going to market, one from injury, the other from unknown cause.

The following is the actual statement of sale and profit after deducting these losses:

ACTUAL FINANCIAL STATEMENT.

Nov. 12, To 60 lambs at $3.00 each	$180.00	
Mar. 12, To cost of food, lot 1	19.38	
Mar. 12, To cost of food, lot 2	17.21	
Mar. 12, To cost of food, lot 3	27.93	
Mar. 12, To value of dead lambs, 173 ℔s. at $4.68 per cwt.	8.09	
Mar. 12, By 2 lambs, trial slaughter		$ 10.90
Mar. 12, By 2 pelts at $1.15 each		2.30
Dec. 12, By 180 ℔s. gain preceding experiment, at $4.68		8.42
Mar. 12, By 56 lambs at $5.00 each		280.00
Mar. 12, To total profit	49.01	
	$301.62	$301.62

After deducting the loss of two lambs and adding the value of the increase during the time preceding the experiment, we have a total gain of $49.01 from the 60 lambs, giving an average per head of 81 cents. The 180 pounds of increase made while the sheep were feeding from stubble, meadows and lanes during parts of November and December, 1899, we have credited as clear gain. We know of no way of determining the value of the waste thus turned into mutton, and which would otherwise have been lost We know of no better way in which to give a farm a good cleaning up, getting rid of grass and weeds along ditches, than by having the sheep do it. After all crops have been harvested a 160 acre farm will furnish food for as many sheep as there are acres for one month, and where sheep are to be fed we strongly advise early purchase and the use of them as suggested.

In order to determine the relative profits from the three methods of feeding, it was necessary to determine the selling price per pound of the lambs, as the gains varied with different lots. As the lambs were sold for $5.00 per head the price per pound was determined from the total weight of the three lots on March 12; this was found to be $4.68 per hundredweight. Now, while only $4.68 could be secured from our local market, at this same time market reports were quoting $6.50 and $7.00 per hundredweight in Chicago. While eastern markets were phenomenally high, it was impossible to find in the Gallatin valley enough of the right sort to make a shipment, and while only $4.68 was being paid locally, there was still a handsome profit of 81 cents per head.

AMOUNT OF FOOD CONSUMED PER DAY AND PER POUND INCREASE.

Lot 1, clover consumed, per head per day	2.13 lbs.
Lot 1, wheat consumed, per head per day	.93 lbs.
Lot 1, clover consumed, per head per lb., increase	6.38 lbs.
Lot 1, wheat consumed, per head per lb., increase	2.8 lbs.
Lot 2, clover consumed per day without grain	3.16 lbs.
Lot 2, clover consumed per pound gain without grain	11.8 lbs.
Lot 3, clover consumed per day with oats	2.15 lbs.
Lot 3, clover consumed per pound gain	6.10 lbs.
Lot 3, oats consumed, per head per day	.93 lbs.
Lot 3, oats consumed, per head per pouud gain	2.65 lbs.

The figures given in table immediately preceeding are for the purpose of showing how much clover was required per head, per day, alone, with wheat, and also with oats. The amounts of clover and oats and clover alone are also given. The amount of clover and grain required were no doubt decreased somewhat by the small amount of turnips, viz.: 42-100 or less than one-half pound per head per day.

Though as shown in lot 2, 11.8 pounds of clover alone was required to produce a pound of gain, this still gives us a good return for each ton of clover converted into mutton. At this rate one ton of clover alone produced 169.5 pounds of gain in live weight, worth at the selling price of $4.68 per cwt, $7.93. Is this not a good market value for one ton of clover? Is it possible to dispose of it at a better advantage in any other way?

In the following table a comparison is made between the lot of Merino grades fed in 1899 and a lot of Shropshires fed in 1900 under exactly the same conditions.

Clover, Oats and Roots.	Gain per mo. pounds.	Cost per cwt. gain.	Clover consumed per ℔. gain.	Grain consumed per ℔. gain.
16 Merino grades, 1899	8.97	$4.62	6.43	2.64
20 Shropshire grades, 1900	10.58	4.39	6.10	2.64

The desirability of proper type for mutton production is here emphasized. The 16 Merino grades were quite typical of the wool producing type; being somewhat small of size, fine of bone, lacking in width at brisket, chest, shoulders and back, and were light in the quarter. The twenty Shropshire grades were almost the reverse of this, and at the same time carried a good fleece. The Merino grades went on feed with an average weight of 42½ pounds, while the Shropshire grades, six weeks older, started with an average weight of 78 pounds. The former, however, were reared on the range only, while the latter had the advantage of ranch conditions. Though the Shropshire grades were nearly twice as heavy at the start, with so much additional weight to maintain, they produced one pound gain from 6.10 pounds clover along with the same amount of grain as the Merinos, which required 6.43 pounds clover. Another important feature, while the Shropshire produced 100 pounds gain from clover oats and roots, (an expensive ration) at a cost of $4.39 per hundredweight, the Merino grades produced the same gain at a cost of $4.62 per hundredweight. But, while the more suitable type gave the best return, still, the results show that that the common range types can also be feed to advantage. Particulars relating to the feeding of the Merino grades can be found in Bulletin No. 21 of this station.

TYPE.

The question of the most suitable type for our conditions is a puzzling one. As we find them at present the type commonly found on the range being more of a wool than mutton producer, and suited to living on scant pastures, does not by any means fulfill the desired requirements of the feed lot. Though crosses of all kinds have been used, as yet the type has not been evolved which has succeeded in entirely fulfilling the widely different requirements of these two spheres. It is a question which will require some careful study and experimenting.

However, so far as the types used in the feed lot are concerned, there is a marked difference in the performance from the two. Those of compact form, with cylindrical bodies, broad well fleshed backs throughout, with wide, deep, full chests, good heart girth and full, rounded, deep quarters gave far the best returns for the food consumed. In selecting for feeding purposes we have found it advantageous to buy where Shropshire, Leicester, Cotswold or Oxford blood had been diffused.

POSSIBILITIES OF MUTTON PRODUCTION IN MONTANA.

The statement has been made frequently that under the conditions prevailing in Montana the sheep industry must necessarily be confined to wool production and the rearing of feeding stocks for export, to be fattened on the cheap grains of the North Central states. Such statements are misleading. Our natural conditions will some day be so utilized that all feeding stocks produced in the state can be fattened here also. The chief reason why this statement is made is because of the large quantities of alfalfa and red clover which can be produced in the numerous valleys. It is true that the valley areas form only a small percentage of the state's area, but these are extremely fertile and produce enormously under irrigation. As an illustration we quote returns from clover crops on the Experiment Station farm in 1900.

From one six-acre tract alone 19 tons and 14 pounds were harvested as a first cutting. The second cutting will yield over two tons per acre, making in all an average of over five tons per acre. This area was accurately measured and the hay well cured before weighing. In fact it was too dry, owing to the delay preventing its removal to the stack at the proper time. The area was irrigated twice. In 1898 a measured acre was sown to clover on May 6, watered lightly on June 29, July 23 and August 15. This acre was harvested on September 6, yielding 3,169 pounds of well cured clover hay To show that this was not unusual, in 1899 a measured acre was similarly treated, was sown on May 13, irrigated June 30 and July 25, only twice, was cut on September 21, yielding 3,090 pounds of well cured hay. The individual acreage of 1900, not yet harvested, promises as good a yield as the two preceding years. In all three instances these acres were preceded by spring wheat. We thus have in 1898, at the end of 113 days from sowing, a crop of 3,169 pounds of cured hay from an acre, and in 1899, which was a more backward season, 3,090 pounds at the end of 131 days. In the face of these facts Gallatin valley's possibilities as to clover production cannot be disputed.

As the Gallatin valley is already noted for its famous barley, club wheat and oats, the question arises, must these be given up to clover? The answer is emphatically no. The valley can continue to produce the same amount of these grains and an enormous amount of clover as well. Only a short time ago not more than one half the area was cropped each year, the other half being summer-fallowed. We are glad to notice that the area of the latter is year by year diminishing, being supplanted by clover, which is dotting the valley with innumerable stacks of hay for feeding purposes and leaving the ground in good condition for barley and wheat. If all the land in Gallatin valley were thus utilized hundreds of thousands of sheep could be fattened annually. Nor is such production limited to this valley. Extensive areas are being used for the growth of alfalfa in the Yellowstone valley, where the yields from three cuttings average from five to seven tons per acre. And what has been said of red clover as a fattening food will apply in much the same way to alfalfa. Tests of this Station, in 1899, showed comparatively little difference in their food values, a slight advantage in favor of clover, more than compensated for by the alfalfa in its larger yield.

Mr. I. D. O'Donnell, of Billings, has been fattening wethers and lambs during several seasons past, using alfalfa without any grain. His work has been pre-eminently successful, and a recent report received from him at this office shows remarkably good gains and very satisfactory profits from the fattening of range lambs on alfalfa alone. Alfalfa, red clover or alsike can be grown, at least one or more of them, in all our valleys to good advantage.

While enormous quantities of clover and alfalfa can be grown in Montana, the area nearly doubling in some sections each year, we are convinced from the results of the work as given that there can be no better way of disposing of this hay than by feeding cattle and sheep during the winter season. A portion, however, will always be required for maintenance of breeding stocks.

One point we wish particularly to emphasize, that though the use of a small quantity of grain along with the clover and alfalfa will increase the gains somewhat and add to the quality that these two hays can be used to good advantage alone. For with lambs on clover alone, consuming 3.16 pounds per day, requiring 11.8 pounds to maintain animal and produce a pound of gain, making a monthly gain of 8.3 pounds. Each ton of clover produced 169.5 pounds gain, worth, at $4.68 per hundredweight, $7.93.

Mr. O'Donnell fed only 4.44 pounds alfalfa per head per day. On this amount his 2's and 3's made an average monthly gain of 8.66 pounds each, while other lots made 6 and 7 pounds per head each month. We consider these good results, as Mr. O'Donnell was feeding alfalfa alone to 10,000 sheep of the ordinary range type, while the Station lambs consisted of sixty select ones of the strictly mutton type. The sheep at Billings were only fed during a 45-day period.

The question of the disposal of finished mutton is one which has confronted our ranchers in a serious way. A number of good lots have been successfully fattened in Gallatin valley, but were found to be too much for local demand. We strongly advise feeding with the view of shipping. Only a comparatively small amount of clover or alfalfa is required to feed a carload of 200 or 220. From the statistics given, calculations can easily be made, allowing of course for a reasonable percentage of waste in the handling. We have found that it will pay to feed from 70 to 90 days and be ready to ship not later than March 1st. The time to begin feeding should be regulated by conditions of weather and available waste food on the ranch, but as a rule it should not be later than December 1st.

CONCLUSIONS.

1. That the less expensive grains can be profitably used along with clover in mutton production. That they will increase the gains and improve the quality. That grains at a high price, such as oats quoted, render the cost of feeding too high, unless used in very small amounts.
2. That either clover or alfalfa will give good returns in fattening sheep and lambs, without the use of any grains.
3. That the result from a given amount of food will depend much on the type of sheep using it.
4. That better value can be obtained from clover and alfalfa converted into mutton than in any other way.
5. That after harvest a few sheep will clean the ranch, utilize what would otherwise waste, and thereby add to the profits.

SWINE FEEDING.

PART III.

The report herein given contains the results of a swine feeding test conducted during a portion of the winter of 1899-1900. While there are many different conditions confronting the pork producer in Montana, this one has been the first to be taken up because of its suggestion by farmers of the state. Though nearly every phase of swine breeding, feeding, etc., has been experimented upon in some part of the country, still we find confronting us conditions which can be met only on our own ground. These relate to foods, climate and market conditions, of which we have a great variety in Montana alone. Our only competition at present are the Eastern packing companies. Montana supplies only a fractional part of the home demand, and until she has secured it all, there can be no chance of prevailing low prices, though local conditions may lead to it at times for a short period only.

The questions are often asked, "Can pork be produced at a profit on grains alone in Montana?" "Can badly damaged grains be utilized with profit in pork making?" "Is there any advantage in feeding roots or clover or alfalfa along with grain?" Many questions such as these come to us through personal enquiry and by means of correspondence. It is the purpose of this report to try to answer some of these questions.

Because of the high prices which generally prevail throughout the state for grains, the question as to their use for pork production is a very pertinent one, and oftentimes the market price will almost prohibit their use. This has been true of oats during the past year, and attention is called to the marked increase in cost of production wherever they are used in these experiments. There is one fact, however, which we should not lose sight of, viz., that with the prices which prevail grains seldom reach a market value at which they can not be marketed to equal advantage in the form of pork.

The plan followed in these tests is not a new one by any means, but simply the trial of practical methods under new conditions. Such foods as alfalfa, clover, peas, mangels, carrots, sugar beets, turnips, etc., have been used at many of the experiment stations, both separately and in conjunction with other foods. The comparative value of sugar beets and alfalfa with some grain, as compared with grain alone, has been the basis of this work. Three lots of pigs of seven each were used. Lot 1 was fed on grain only, consisting during a part of the time of damaged wheat and oats, in proportion by weight of two parts wheat and one part oats. During the latter part of the test barley was substituted for the wheat. By way of explanation: The wheat being late had been frozen, and had heated later, despite all efforts to prevent it by shoveling. It formed a portion of the ration of all three lots during the first forty days. Lot 2 were fed the same grain mixture as lot 1, viz: wheat and oats, but in less quantity, sugar beets forming a part of the ration. These were fed whole and raw, and were greatly relished. Lot 3 were given the same grain mixture as 1 and 2, but along with alfalfa. It is generally conceded that alfalfa is valuable as a food for hogs, and in many cases where grain is not available large quantities of this food are consumed by swine which are being wintered over. We know of cases where pigs have wintered well simply from alfalfa stacks. But as the claim has been made that it enhances the return from grain food fed, we attempted to obtain specific data. In order to do this the alfalfa used was run through a cutting-box, reduced to chaff, moistened, and mixed with meal. This method was necessary in order to get at the actual amount consumed. In ordinary practice it is fed whole, the hogs being allowed to select the leaves and finer particles. The alfalfa in this case formed part of a forced ration.

The pigs used for feeding were twenty-one shotes, having an average weight of 112 pounds. They consisted of a Berkshire cross on high-grade Poland China sows. They were in a thrifty condition, but not fat, having been allowed to glean from a limited area of stubble with some clover pasture. Three weeks before trial began they were put on preliminary feed, and prepared for the test. The following table gives the total amount of food consumed during the experiment:

TABLE NO. 1.

FOOD CONSUMED BY LOT 1 GETTING GRAIN ONLY.

Date.	Wheat pounds	Oats pounds.	Barley pounds,	Total Grain pounds.
Dec. 29th, 1899, to Feb. 7th, 1900	1,102⅔	551⅓		1,654
Feb. 7th, 1900, to Mar. 5, 1900		437⅔	875⅓	1,313
Totals	1,102⅔	989	875⅓	2,967

FOOD CONSUMED BY LOT 2 GETTING GRAIN AND SUGAR BEETS.

Date.	Wheat pounds.	Oats pounds.	Barley pounds.	Total Grain pounds.	Roots pounds.
Dec. 29th, 1899, to Feb 7th, 1900	971⅓	485⅔		1,457	410
Feb. 7th, 1900, to Mar. 5th, 1900		348⅔	693⅓	1,040	409
Totals	971⅓	832⅓	693⅓	2,497	819

LOT 3 FEEDING ON GRAIN AND ALFALFA.

Date.	Wheat pounds.	Oats pounds.	Barley pounds.	Total Grain pounds.	Alfalfa pounds.
Dec. 29th, 1899, to Feb. 7th, 1900	1,010⅔	505⅓		1,516	219
Feb. 7th, 1900, to Mar. 5th, 1900		389	778	1,167	151
Totals	1,010⅔	894⅓	778	2,683	370

Attention is called to the fact that lot No. 1, feeding on grain only, consumed by far the largest amount of the three, and yet failed to make a relatively greater gain. Taking into consideration the grain portion of the ration only, the following amounts were required to produce a pound of increase:

Lot 1.	Grain required to produce a pound of increase	5.32 lbs.
Lot 2.	(Receiving sugar beets), grain required to produce a pound of increase	4.26 lbs.
Lot 3	(Receiving Alfalfa), grain required to produce a pound of increase	4.86 lbs.

It will also be noticed that the amounts of the various grain portions of the ration differ slightly in the actual weight consumed. This is according to the plan outlined, the intention being to force sugar beets and alfalfa into the rations and thus to determine definitely their influence, not only as food factors, but also the effect upon the results from the grain foods with which they were used. That the effect upon the digestion and assimilation of the nutriments was marked is shown by the smaller amounts of grain required to produce a pound of gain, in the cases where alfalfa and sugar beets were used, as shown in the tables immediately preceding. Where these are used in a forced ration there is some danger of rendering the food too bulky, particularly in mixing meal and alfalfa. While a bulky ration may answer well for store hogs and breeding stocks, it is detrimental to a rapid gain where the object is to produce flesh quickly. This is one reason in favor of allowing hogs free access to alfalfa in racks, rather than forcing it into the ration. They will then consume only the fine and more nutritious parts, rejecting the coarse, bulky, inedible portions.

In the following table, No. 2, are given the gains of the three lots throughout the two periods during which wheat was first used and then replaced by barley:

TABLE NO. 2.

INCREASE FROM FOOD USED.

(Seven hogs in each lot.)

Lot.	Wt. Dec. 29, 1899, pounds.	Wt. Feb. 7, 1900, pounds.	Wt. Mar. 5, 1900, pounds.	Total increase, pounds.
1.	780	1,072	1,337	557
2.	801	1,100	1,387	576
3.	779	1,059	1,331	552

AVERAGE DAILY GAINS.

Lot 1, Fed grain only. Average daily gain during first forty days while receiving damaged wheat	1.04 lbs.
Lot 1, Average daily gain during second period of twenty-six days while receiving barley	1.46 lbs.
Lot 2, Fed grain and roots. Gain per head per day during first forty days while receiving damaged wheat	1.06 lbs.
Lot 2, Gain per head, per day, during second period of twenty-six days with barley	1.50 lbs.
Lot 3, Fed grain and alfalfa. Gain per head, per day, during first forty days while receiving damaged wheat	1 lb.
Lot 3, Gain per head, per day, during second period while receiving barley	1.49 lbs.

AVERAGE GAIN THROUGHOUT TEST.

Lot 1, Gain per head, per day	1 20 lbs.
Lot 2. Gain per head, per day	1.26 lbs.
Lot 3, Gain per head, per day	1.19 lbs.

In the following, table No. 3, the cost of the foods used is given for each lot.

TABLE NO. 3.

COST OF FOOD, LOT 1.

Wheat, 1,102⅔ lbs., at 40c per cwt	$ 4.41
Oats, 989 lbs., at 90c per cwt	8 90
Barley, 875⅓ lbs. at 60c per cwt	5.25
	$18.56

COST OF FOOD, LOT 2.

Wheat, 971⅓ lbs, at 40c per cwt	$ 3.88
Oats, 832⅓ lbs., at 90c per cwt	7.49
Barley, 693⅓ lbs., at 60c per cwt	4.16
Sugar Beets, 819 lbs, at 15c per cwt	1.22
	$16.75

COST OF FOOD, LOT 3.

Wheat, 1,110⅔ lbs., at 40c per cwt	$ 4.04
Oats, 894⅓ lbs., at 90c per cwt	8.04
Barley 778 lbs., at 60c per cwt	4 66
Alfalfa, 370 lbs, at $6.00 per ton	1.11
	$17.85

The value placed on the foods used were those prevailing at the time they were fed. In the case of the wheat a valuation was made by experienced mill men, unacquainted with the purpose of its use, and who could give a disinterested opinion. The value placed upon sugar beets, viz., that of $3.00 per ton, is much greater than the estimated cost of production in some of the neighboring states, their estimate being $2.00 per ton. While Minnesota farmers may produce them at 9 cents per hundredweight, the value used in a recent bulletin, we find that with more expensive labor 12 to 15 cents per hundredweight is about what they cost in Montana. We hope to secure data ere long giving full particulars as to the cost of raising sugar beets under Montana conditions.

In looking over table No. 3, the most striking difference in the cost of the oats as compared with wheat and barley will be noticed. Pound for pound the oats increased the cost of production at a rate of nearly double that of the other two. So that granting they possess a great value, we deem it advisable to use them only in small proportion in fattening rations with prices ranging as at present. This feature is especially marked, as was shown in the case of the sheep fed on clover and oats as compared with those fed on clover and other grains.

In the following table are found the statistics relating to the financial outcome of the experiment. A valuation of 5 cents per pound was placed on the shotes, averaging 112 pounds at beginning of experiment. The estimated value was fixed by a local dealer who understood the prices then prevailing. The hogs were disposed of in three lots, one to a local butcher, one to a rancher, and the balance were sent to Helena along with a shipment of steers. The average price obtained was 5¼ cents per pound, live weight. About the same time two lots from the country near by, one of 150 head and the other of 50, were sold at the same price by live weight. In buying hogs to fatten a wider margin between buying and selling price is safer, the estimated value in this case being high, though it then prevailed.

FINANCIAL STATEMENT.

LOT 1.

Cost of 7 hogs, lot 1, Dec. 29, 1899, weight 780 lbs., at 5c	$39.00	
Cost of food, lot 1, Dec. 29, 1899 to Mar. 5, 1900	18.56	
Total cost		$57.56
Value of hogs at close of experiment, weight 1,337 lbs., at 5¼c.		70.19
Net profit		$12.63

LOT 2.

Cost of 7 hogs, lot 2, Dec. 29, 1899, weight 801 lbs., at 5c	$40.05	
Cost of food, lot 2, Dec. 29, 1899, to Mar. 5, 1900	16.75	
Total cost		$56.80
Value of hogs at close of experiment, weight 1,387 lbs., at 5¼c.		72.81
Net profit		$16.01

LOT 3.

Cost of 7 hogs, lot 3, Dec. 29, 1899, weight 779 lbs., at 5c	$38.95	
Cost of food, lot 3, Dec. 29, 1899, to Mar. 5, 1900	17.85	
Total cost		$56.80
Value of hogs at close of experiment, weight 1,331 lbs, at 5¼c.		69.87
Net profit		$13.07
Total net profit from the three lots		$41.71

PROFIT PER HEAD BY LOTS.

Lot 1. On grain only. Net profit per head	$1.80
Lot 2. On grain and beets. Net profit per head	2.28
Lot 3. On grain and alfalfa. Net profit per head	1.87
Average net profit per head for three lots	1.98

In following out this line of work some important practical conclusions have been reached by careful observation during the progress of the experiment. The statistics show that damaged grain can be utilized profitably in pork production, where it would be otherwise difficult to dispose of it, and that while the gains are not proportionately as large as those from good grain, still they are satisfactory. The conclusion was also reached that with badly damaged wheat, pigs will eventually show a distaste for it, and that a change to some other form of food is desirable for a short period in order to give them the proper finish. So far as uninjured wheat is concerned in the production of pork, Prof. H. F. French, now of Idaho, but formerly connected with the Oregon Station, says with regard to the quality of wheat fed pork: "Fat is heavy and thick and firm in texture, and the lean meat is juicy and light in color."

As regards the use of sugar beets as a pig food, the results show they have good value. A value derived not so much from the nutrients in the dry matter which they contain as from the influence they exert on digestion and assimilation. Proof of this is found in the fact that where 5.32 pounds of grain alone were required to produce a pound of gain, 4.26 pounds of grain produced a pound of gain when a small quantity of beets was also given. As sugar beets contain 86.5 per cent. water, the 819 pounds fed to lot 2 would only supply to them 110 pounds of dry matter. So that the smaller portion of grain required to produce a given gain cannot be entirely accounted for by the nutritives supplied in the dry matter of the sugar beets. We have found that pigs soon become very fond of sugar beets, and that they can be fed to good advantage raw; that there is no advantage to be derived from cooking them. They should not, however, be fed in larger quantities than from 2 to 2½ pounds per day to a 150 pound animal. If fed too freely they have a laxative effect on the digestive organs, and cause some loss to the grain fed. They have given us good results fed in larger quantities to store hogs receiving very little grain during the winter. In this way store hogs can be wintered over very cheaply and come out in good thrifty condition. Their value extends also to the brood sow; we have for several years made them a part of her ration. They have a tendency to prevent a torpid condition of the digestive tract, render parturition more easy, increase the flow of milk and produce a vigorous offspring. It is necessary, however, to use the precaution not to give beets except in small quantities to the sow during the first week after farrowing. They are liable to affect the milk, causing bowel trouble among the young pigs.

What has been said of sugar beets will apply in very much the same way to mangels and carrots. The food value of all three for swine is very much alike. It can be said of carrots, however, that they are very much more expensive than either sugar beets or mangels, owing to the labor involved in giving them the proper cultivation and the difficulty found in harvesting. According to Danish feeding experiments carrots and mangels have about a similar value in feeding. Under conditions frequently found in Montana the sugar beet is preferable to the mangel for the reason that they keep much better during the winter season. The mangel which grows out of the ground, with a sparse top for covering, is frequently touched by an early frost, and then will not keep well. As the sugar beet makes its growth within the ground and the crown is well covered with leaves, early frosts, even very severe ones, will not do any damage. During the last two years we have had sugar beets to feed as late as the middle of June.

The argument most strongly urged against the use of roots is that they are expensive to raise. On the average farm only a very small area is required to produce an abundance of pig feed. One acre will produce at a fair average not less than ten to twelve tons of beets, and these if properly treated will not cost more than $25.00 per acre. They are in reality one of the most economical foods.

While turnips and rutabagas can be grown in Montana with even a greater tonnage return per acre than sugar beets or mangels, they cannot be used to advantage as pig food. Pigs will refuse to eat them raw, and cooking is too expensive to render their use in that way profitable. Cooked and with meal added they are readily consumed.

As shown by the figures given, the use of alfalfa in a fattening ration for pigs has been attended with good results, though not quite equal to that of sugar beets. While the alfalfa was finely cut for these tests, we do not advocate the practice. The Kansas Experiment Station obtained good results by merely supplying it whole, allowing the pigs to use what they would. This is no doubt the most practical way. When cut and mixed with meal the ration then becomes a forced one and is too bulky. Leaves and chaff may be used to good advantage in this way, and where fed in very cold weather, should be given in the morning, moistened, with the meal sprinkeled on. When cut material or chaff and leaves are fed with the grain, flat-bottomed troughs are necessary, with slats nailed across the top every eighteen inches, to prevent wasting. Some time is required before pigs relish an alfalfa ration. They do not take to it so readily as to sugar beets.

IMPORTANT FACTS SUMMARIZED.

PROFITS FROM EACH LOT.

Lot 1.	Seven pigs on grain only, for 66 days, gave net profit	$12.63
Lot 2.	Seven pigs on grain and sugar beets, for 66 days, gave net profit	16.01
Lot 3.	Seven pigs on grain and alfalfa, for 66 days, gave net profit	13.07
	Total net profit	$41.71

PROFITS PER HEAD.

Lot 1.	Fed grain only	$ 1.80
Lot 2.	Fed grain and sugar beets	2.28
Lot 3.	Fed grain and alfalfa	1.87
	Average net profits, per head, from lots 1, 2 and 3	$1.98

COST OF INCREASE.

Lot 1.	Fed grain only, per cwt	$ 3.33
Lot 2.	Fed grain and sugar beets, per cwt	2.85
Lot 3.	Fed grain and alfalfa, per cwt	3.23

RELATIVE GAINS.

Lot 1.	Where damaged wheat formed part of ration, per day	1.04 lbs.
Lot 2.	Where damaged wheat formed part of ration, per day	1.06 lbs.
Lot 3.	Where damaged wheat formed part of ration, per day	1.00 lbs.
Lot 1.	Where barley formed part of ration, per day	1.46 lbs.
Lot 2.	Where barley formed part of ration, per day	1.50 lbs.
Lot 3.	Where barley formed part of ration, per day	1.46 lbs.

AVERAGE GAIN THROUGHOUT THE WHOLE PERIOD.

Lot 1	1.20 lbs , per head, per day.
Lot 2	1.26 lbs , per head, per day.
Lot 3	1.19 lbs., per head, per day.

FOOD REQUIRED FOR A GIVEN GAIN.

Lot 1.	Fed grain only, required	5.32 lbs , grain, per lb. gain.
Lot 2.	Fed grain and sugar beets	4.26 lbs , grain, per lb. gain.
Lot 3.	Fed grain and alfalfa	4.86 lbs , grain, per lb. gain.

CONCLUSIONS.

1. That sugar beets are a valuable adjunct to use along with grain foods for fattening hogs. While the small percentage of nutrient contained in them is of value, the beneficial effects produced on digestion and the assimilation of other foods is very marked. The figures indicate that by their use a saving of grain is effected, and the quality of the meat improved.

2. That alfalfa as a food adjunct for fattening hogs is valuable. While it should not be forced into a ration, cut and mixed with meal in such large quantity as to render it bulky, small quantities can be used to good advantage in this way, or supplied whole in racks. It lessens the cost of production, aids in keeping the animals in a good thrifty condition, and improves the quality of the meat produced. We have not found its use equal to sugar beets or mangels.

3. That a straight grain ration, though it produces a rapid gain, is the most expensive method of feeding.

4. That damaged grain cannot be utilized to better advantage than when converted into pork.

5. That grains seldom reach a market price in Montana at which they cannot be marketed to equal advantage in the form of pork.

Much of the success attending these lines of stock feeding is due to the careful observation and performance of all the details relating thereto, by Mr. Charles Wilson, who was in charge of the work.

R. S. SHAW.

30.679
M19a2b

BULLETIN NO. 28.

Montana Agricultural Experiment Station

......OF......

THE MONTANA COLLEGE OF AGRICULTURE.

Seventh Annual Report of Treasurer, Director, Horticulturist, Botanist, Entomologist, Chemist, Agriculturist and Irrigation Engineer.

BOZEMAN, MONTANA, JULY, 1900.

ROCKY MOUNTAIN HUSBANDMAN
White Sulphur Springs,
MONTANA.

Montana Agricultural
EXPERIMENT STATION.

LETTER OF TRANSMITTAL.

To His Excellency, Robert B. Smith, Governor of Montana:

Bozeman, Montana, July 1, 1900.

DEAR SIR—I have the honor to transmit to you herewith the Seventh Annual Report of the Montana Agricultural Experiment Station.

Respectfully,
S. M. EMERY, Director.

EXECUTIVE BOARD.

LESTER S. WILLSON, President	Bozeman
PETER KOCH, Secretary and Treasurer	Bozeman
GEORGE KINKEL, JR., Vice-President	Bozeman
WALTER S. HARTMAN	Bozeman
JNO. M. ROBINSON	Bozeman

EXPERIMENT STATION STAFF.

S. M. EMERY,	Director and Horticulturist.
F. W. TRAPHAGEN, Ph. D., F. C. S	Chemist.
ROBT. S. SHAW, B. S. A	Assistant Agriculturist.
J. W. BLANKINSHIP, Ph. D	Botanist.
SAMUEL FORTIER, MA. E	Irrigation Engineer.
R. A. COOLEY, B. S	Entomologist.

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director.

MONTANA EXPERIMENT STATION,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana (so long as the supply lasts) who sends his name and P. O. address to the Station for that purpose.

Report of Treasurer of Board.

The Experiment Station of the Agricultural College of the State of Montana in Account with The United States Appropriation, 1899-1900:

DR.

To Receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1900, as per Act of Congress approved March 2, 1887	$15,000 00

CR.

By	Salaries	$ 8,408 47
	Labor	3,032 75
	Publications	257 34
	Postage and stationery	140 55
	Freight and express	339 16
	Heat, light and water	439 90
	Chemical supplies	51 16
	Seeds, plants and sundry supplies	464 36
	Fertilizers	8 50
	Feeding stuffs	51 93
	Library	26 25
	Tools, implements and machinery	470 77
	Furniture and fixtures	129 29
	Scientific apparatus	860 37
	Live stock	150 00
	Traveling expenses	59 30
	Contingent expenses	10 00
	Total	$15,000 00

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Experiment Station of the Agricultural College of the State of Montana for the fiscal year ending June 30, 1900; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000, and the corresponding disbursements $15,000; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

Attest: Signed:

PETER KOCH.

PETER KOCH,
W. L. HARTMAN, } Auditors.

MONTANA EXPERIMENT STATION.

Bulletin No. 28. *July, 1900*

Annual Report of the Director for Fiscal Year Ending June 30, 1900.

STATION STAFF.

No changes have been made in the Station staff, except the promotion of Robert S. Shaw from Assistant Agriculturist to Agriculturist. This change was made at the request of the Director.

FARMERS' INSTITUTES.

Interesting sessions were held at the following places in the winter of 1899 and 1900:

Miles City, Canyon School House, Laurel and Park City, Gebo, Bridger, Bozeman and Great Falls. These sessions, usually three or more in a place, were conducted by the Experiment Station staff, aided by local talent.

Purely horticultural meetings were conducted by Director Emery and Prof. R. A. Cooley at Holt and Kalispell, Flathead county.

There is a manifest interest in Institute work in the state, and through these meetings it is possible to give to the farmers a partial idea of the various experiments that are being conducted at the Station for their benefit.

Restricted as is the Station by a lack of funds from extended publication of bulletins covering the work in detail, farmers' institutes giv the next best opportunity to present the result of agricultural investigations to those who are the most interested in them, the farmers of the state.

Montana will doubtless soon copy the example of the leading agricultural states of the Union and place this important work upon a sound financial basis by making a sufficient annual appropriation for systematically carrying on the work.

PRESS LIST.

The following publications have come regularly to the Experiment Station in exchange for its bulletins. We hereby make public acknowledgement of the courtesy thus shown to us :

Independent, Helena
Inter Mountain, Butte
Missoulian, Missoula
Northwest Agriculturist, Minneapolis
Butchers' Advocate, New York
Dorset Courier, Washington, Pa
Dixie Miller, Nashville, Tenn
Elgin Dairy Report, Eldin, Ill
Field and Farm, Denver, Col
Farm News, Springfield, Ill
Farm, Stock and Home, Minneapolis
Farmers' Guide, Huntington, Ind
Florists Review, Chicago
American Gardening, New York
Green's Fruit Grower, Rochester, N Y
Hoard's Dairyman, Ft Atkinson, Wis
Forester. Philadelphia, Pa
Farm Journal. Philadelphia, Pa
Farm Student's Review, St Anthony's Park, Minn
Holstein Register, Brattleboro, Vt
Home and Garden, St Paul, Minn
Home and Farm, Louisville, Ky
Horticultural Visitor, Kidmundy, Ill
Jersey Bulletin, Indianapolis, Ind
Irrigation Age, Chicago
Edwards' Fruit Grower, Missoula, Mont
The Farmer, St Paul, Minn
Nebraska Farmer, Omaha, Neb
Rocky Mountrin Husbandman, White Sulphur Springs, Mont
National Stockman and Farmer, Pittsburg, Pa
North American Horticulturist, Munroe, Mich
Wallace's Farmer, Des Moines, Ia
Wisconsin Agriculturist, Racine. Wis
Western FruitGrower. St Joseph, Mo
West Virginia Farm Review, Charleston, W Va
Farm and Poultry, Boston
Inter State Poultryman, Tiffin, O
American Poultry Journal, Chicago
Poultry Keeper, Parkersburg, Pa
Poultry Monthly, Albany, N Y
Poultry Culture, Kansas City, Mo
Pacific Poultryman, Tacoma, Wash
Poultry Herald. St Paul. Minn
The Feather, Washington, D C
Weekly Sun, Baltimore, Md
The World, Vancouver, B C
Avant Courier, Bozeman, Mont
Belt Valley Times, Belt, Mont
Billings Times, Billings, Mont
Pioneer, Big Timber, Mont
Bozeman Chronicle, Bozeman, Mont
Inter Lake, Kalispell, Mont
College Exponent, Bozeman, Mont
Tribune, Dillon, Mont
Independent, Glendive, Mont
Post, Livingston, Mont
Enterprise, Livingston, Mont
Mining World, Butte, Mont
Journal, Milwaukee, Wis
Madisonian, Virginia City, Mont
Northwest Tribune, Stevensville, Mont
Sentinel, Boulder, Mont
Stock Growers' Journal, Miles City
Tribune Review, Butte, Mont
Tribune, Great Falls, Mont
Western News, Hamilton, Mont
Yellowstone Journal, Miles City. Mont
The News. Miles City, Mont
Carbon County Democrat, Red Lodge. Mont
Orange Judd Farmer, Chicago
Park and Cemetery, Chicago
Rural New Yorker, New York
The Farm Home, Springfield, Ill

Agricultural Epitomist, Indianapolis, Ind
Ruralist, Federalsburg, Md
Stockman and Farmer, Helena, Mont
Garden and Farm, Reed City, Mich
Fergus County Democrat, Lewistown
Field and Stream, N Y
Strawberry Specialist, Kittrell, N C
Western Swine Breeder, Lincoln Neb
News, Libby, Mont
Plainsman, Plains, Mont
Oregon Agriculturist, Portland, Ore
Northwest Horticulturist, Tacoma, Wa
Dispatch, St Paul
Daily Drovers' Journal, Chicago
Dairy and Creamery, Chicago
Western Creamery, San Francisco
The Beet Sugar Gazette, Chicago
The Ohio Farmer, Cleveland, O
Ranch and Range, Spokane, Wash
Farmer's Tribune, Des Moines, Ia
National Farmer and Stock-Grower, National Stock Yards, Ill
Holstein Freisian Register, Brattleboro, Vt.
Wool and Sheep Markets, Chicago, Ill
North Pacific Rural Spirit, Portland, O
Weekly Chronicle, San Francisco

Respectfully submitted,

S. M. EMERY, Director.

Report on Horticulture.

[The following abridged notes on horticulture for the year have been compiled by the Station from the report of the horticulturist, Director S. M. Emery:]

ORNAMENTAL SHRUB CULTURE.

After three seasons' cultivation at this Station of the fifty varieties of socalled "hardy" deciduous shrubs given below, we are able to group them roughly as follows:

I—HARDY.

Berberis Canadensis, American Barberry.*
Berberis vulgaris, European Barberry.*
Berberis vulgaris purpurea, Purple-leaved Barberry.*
Cornus sanguinea, Crimson Dogwood.*
Ligustrum, White-berried Privet.*
Ribes aureum, Yellow-flowering Currant.
Symphoricarpus racemosus, White Snowberry.*
Syringa caerulea superba, Lilac.
Syringa villosa.
Syringa vulgaris, Louis Spath.
Syringa vulgaris, Princess Alexandria.
Viburnum opulus sterilis, Snowball.

II—SEMI-HARDY.

Berberis Aquifolia, Mahonia.**
Elæagnus longipes, Silver Thorn.**
Hydrangia pauiculata grandiflora.**
Lonicera Tartarica alba, White-flowering Honeysuckle.**
Lonicera Tartarica grandiflora, Pink-flowering Honeysuckle.**
Prunus triloba, Double-flowering Plum.
Pyrus Japonica, Japan Quince, Scarlet.**
Pyrus Japonica, Japan Quince, Blush.**
Pyrus Japonica, Japan Quince, Rose.**
Rhus glabra laciniata, Cut-leaved Sumac.**
Sambucus nigra aurea, Golden-leaved Elder.**
Sambucus nigra laciniata, Cut-leaved Elder.**
Spiræa Van Houttei.
Syringa, Garland.**
Syringa, Golden.
Syringa, Large-flowering.
Tamarix.
Viburnum.
Syringa rothomagensis.

---

*Young wood slightly winter-killed.
**Young wood half killed back each winter.

III—POOR OR USELESS.

Calycanthus.***
Clethra alnifolia.***
Deutzia gracilis.***
Deutzia scabra.***
Deutzia Pride of Rochester.***
Euonymus atropupureus, Red-fruited Euonymus.***
Euonymus Europæus fructo-alba, White-fruited Euonymus.***
Forsythia Fortunei.***
Forsythia intermedia.***
Hibiscus Syriacus, White Althæa.°
Kerria Japonica.***
Ligustrum ovalifolium, California Privet.°
Prunus Pissardi, Purple-leaved Plum.
Rhus Cotinus, Purple Fringe.***
Spiræa Bumalda.***
Spiræa prunifolia.°
Weigela Desboisii.***
Weigela P. Duchartre.
Weigela rosea variegata.

***Killed down each winter.
°Killed completely.

All of group I will grow in nearly every part of the state except the high mountains. Most of group II will doubtless be found to grow well in the larger valleys west of the Divide, while those in group III can hardly be expected to be grown successfully anywhere in the state without winter protection.

EXPERIMENTS IN FRUIT CULTURE.

APPLE.

The older trees below mentioned have been set out five years and all of them at least three, so that we are able to determine in general their relative hardiness and the bearing qualities of a part of this number at this Station.

I—HARDY.

Little, if any, winter killed.

Anisette*
Bogdanoff
Ben Davis
Duchess of Oldenburg*
Gano
Gipsey Girl
Good Peasant
Gideon**
Hibernal**
Lead 3 n
Longfield*
Number Twelve*
Orel**
Okabena*
Royal Table**
Thompson's No. 10
Voronesh
Wealthy**
Yellow Transparent
Zuzoff

II—SEMI-HARDY.

The annual growth is killed back half or more each winter.

Alexander
Allen's Choice
Charlottenthaler
Early Harvest
Early Strawberry
Liebe
McIntosh Red
McMahon's White
Northern Spy
Pewaukee
Persian
Plumb's Cider
Price's Sweet
Red Astrachan
Scott's Winter
Tetofsky
Walbridge

III—POOR OR WORTHLESS.

Almost or completely killed.

Red Queen
Salome

---

*Not bearing.
**Fruit fell off before maturity.

CRABS.

All these except Whitney and Orange are hardy at this Station. Those starred (*) are now bearing; the Martha bloomed but bore no fruit.

Bailey's Crimson*
Florence
Greenwood*
Hyslop*
Martha
Orange*
Pride of Minneapolis*
Russet Crab*
Transcendent*
Whitney No. 20
White Arctic

PEARS.

A number of varieties have been tried but none found hardy at this Station.

CHERRIES.

Here, at least half of each annual growth is winter-killed and no fruit has been borne after six years' trial of the three varieties below :

Bessarabian **Sklanka**
Griotte du Nord

PLUMS.

Weaver, DeSoto and Forest Garden—New growth half winter-killed and the fruit set freezes before maturity.

Yellow Voronesh—No fruit set.

Moldavka—Hardy and fruit matured this season.

A new orchard containing 125 varieties of fruit trees, five of each, was set out in 1899 and is in process of being tested as to the relative hardiness and bearing qualities of the several varieties. Also in the spring of 1900 root-grafts were made of some 200 different varieties, 40 to 100 of each, and these will be tested in the same way in order to determine their hardiness in this climate.

Studies are being made in the causes of the bursting of the stems and twigs of fruit trees during the sudden changes of temperature in the winter and the effect of late irrigation, subsequent pruning and transplanting the following spring in preventing such bursting or in saving the trees affected, but the data at hand seem hardly to warrant definite conclusions.

An attempt has also been made to determine the relation between the relative maturity of the terminal buds at the beginning of winter and the hardiness of the variety; and, in general, it would seem that the more hardy apples and crabs mature their wood and terminal buds earlier than the less hardy varieties, but there seems to be little or no correspondence between bud-maturity and the bark-bursting of the stems and twigs.

The Station has had a curious experience in transplanting certain apple trees, in which ten apparently healthy trees remained an entire season dormant and did not put forth leaves till the following spring. Eight of these trees subsequently died, but the other two are healthy and have since made vigorous growth.

In the spring of 1900 an experiment was made in planting by the Stringfellow system. Eighty-nine trees of the Wealthy and Alexander apple—mainly one-year grafts in two- and three-year stocks—were set out by this method. All side roots were cut back close to the tap-root, the latter itself shortened to six or eight inches and the stems cut to about twelve. These were then planted with a crowbar in clean, mellow soil and irrigated twice before July 1; at that date about 18 per cent. of the trees were dead, 56 per cent. were in good condition and the rest weak. The fact that 75 per cent of the dead trees are the Alexander would indicate a marked difference in the ability of the different varieties to withstand this treatment.

Report of the Agriculturist.

To the Director:

I herewith submit my report for the year ending June 30, 1900:

The work of this department comprised a continuance of tests with varieties of wheat, oats, barley, potatoes, grasses and forage and fodder plants. The third season's work of the six year rotation test was also carried out. Live stock feeding tests with cattle, sheep and swine were made during the winter season. In addition to this there was the work of supervision of farm labor and direction of the general farm work and improvement.

Sixty-seven varieties of spring wheat, forty-eight of oats and twenty-five of barley were grown in plats. These consisted of the ones tried the previous year with a few additions. Owing to the fact that these varieties were tested in '98 under the "Campbell system," as described in the Sixth Annual Reyort, and in '99 under general farm culture methoes, the work of selection was greatly impeded. The comparative results were as follows :

By Campbell system in '98—

Average yield per acre from 66 varieties spring wheat, 32.41 bu.

Average yield per acre from 46 varieties oats, 33.11 bushels.

Average yield per acre from 26 varieties barley, 27.05 bushels.

By general farm culture method in '99—
Average yield per acre from 67 varieties spring wheat, 43.84 bu.
Average yield per acre from 48 varieties oats, 72.54 bushels.
Average yield per acre from 25 varieties barley, 50.86 bushels.

We conclude that the Campbell system will not compete with methods of irrigation, though it may hold an important place in crop production in arid regions where water is not available.

As the result of the variety testing of '99 several each of the wheat, oats, barleys and potatoes were found to possess valuable qualities under our state conditions and were selected for increase and subsequent distribution. The testing of grasses, both with and without irrigation, was continued. This work must necessarily continue throughout several seasons before reliable results can be secured.

The yields from the rotation acreage for '98 were:
Acre of wheat, 52⅛ bushels.
Acre of oats, 78 bushels.
Acre of barley, 68 bushels.
Acre of clover, 3090 lbs. hay.
Acre of peas, grain, 2070 lbs.
Acre of peas, straw, 3360 lbs.
Acre of sugar beets, 15631 lbs.

So far as the test has progressed we find very little fluctuation from year to year, even though the cropping is continuous. Owing to different climatic conditions from year to year, and the effect of these on the mechanical condition of the soil, its water content, evaporation, etc., the producing power of these six acres cannot be estimated until the expiration of the six years. We can conclude now, however, that where the grain crops follow peas, clover and cultivated crops, the yields are fully as good as those secured after summer fallowing. That while this six year rotation may succeed in maintaining soil fertility a shorter one will be more practical for the Montana farmer.

The results of the live stock feeding tests have already been reported in Bulletin No. 27. The object of this work was to obtain data relating to the use of legumes as fattening foods. The growth of these in Montana is increasing at a marvelous rate. Where clover succeeds best it is rapidly superseding the summer fallow. All feeding work has been carried on with a view to stimulating winter feeding and thus secure the greatest possible return from the clover and alfalfa produced.

The results from fattening steers showed :

(1). That good results can be secured from clover with a minimum amount of grain.

(2) That a small amount of barley meal fed to steers along with clover, not exceding one-half to three-quarters of a pound of meal per one hundred pounds of live weight of cattle each day, will greatly add to the gains and quality of meat produced. Any excess above this amount will not give a proportionately greater gain and will materially add to the cost of production.

(3). That in selecting steers of the best type it is essential to use only those of the beef breeds. Those of the beef type made a gain of 2.55 pounds per day as compared with a gain of 1.73 pounds from the untypical ones on the same feed. The best type produced 100 pounds increase at a cost of $4.84, while the same increase from untypical ones cost $5.55 per cwt.

(4). That with high, dry feeding grounds and constant access to water, with straw sheds for shelter, good returns can be made from fattening steers.

Results from fattening sheep showed :

(1). That the less expensive or damaged grain can be used to good advantage along with clover.

(2). That first-class, marketable grains increase the cost of production too much if used in large quantity.

(3). That clover alone will give good results without any grain.

(4). The best results from increase and quality are obtained from clover and a limited amount of grain.

(5). That after harvest sheep will clean the ranch, utilizing the waste material, thus adding to the profits.

Results from fattening swine showed :

(1). That sugar beets are a valuable adjunct to use along with grain. They diminish the cost of production and improve the quality of the meat.

(2). That access to alfalfa will aid in the fattening, but should not be forced into the ration.

(3). That a straight grain ration, though it produces a rapid gain, is an expensive method of producing pork.

(4). That grains seldom reach a market value in Montana at which they cannot be marketed to equal advantage in the form of pork.

What has been said of clover, as used throughout these experiments, applies in much the same way to alfalfa.

In addition to the feeding tests already mentioned, the first of a series of pasturage experiments was started on June 9th, 1900.

By way of improvement the two roads intersecting the farm were graded to provide dry and solid driveways at all times, but more especially during the irrigation season. A small portion of swampy land near the Station building was reclaimed by drainage and grading and other ditches opened up on another tract preparatory to laying drains. Some eight or ten acres of the Station farm will have to be reclaimed in this way.

Methods of cultivating and cropping were also brought into use for the purpose of determining an economical system of weed eradication and at the same time receive some crop return from the land so infested. The progress of this work will be reported on from time to time.

Respectfully submitted,

R. S. SHAW, Agriculturist.

Report of the Chemist.

Bozeman, Montana, June 30, 1900.

Mr. S. M. Emery, Director Montana Experiment Station :

DEAR SIR :—Following is a brief report of the work of my department for the fiscal year just ended :

In all we have made three hundred and twenty analyses during the year.

The work on alkali soil and sugar beets has been continued with results supporting previous determinations.

Analyses of the ash of plants particularly of alfalfa hay, grown on alkali land and on land free from alkali, have shown that large quantities of the typical alkali salts are removed with the crops.

As much as ten times the amount existing in ordinary hay has been found to be present in hay harvested from alkali soil.

Tables of analyses showing the relations of ash in hays from various localities are being prepared for publication.

Analyses of waters used for irrigation and for watering live stock are still being made and the result will be published soon.

A large number of eggs have been analyzed for the poultry department to determine whether there is a definite increase in the two important food-principles of the egg when the hen is carefully fed, and whether different foods affect the character of the egg. These analyses will appear in the forthcoming bulletin on Poultry Feeding.

The various insecticides on sale in the state so far as collected have been shown to be without exception remarkably pure and all above the fifty per cent. arsenious acid content adopted by many states as the legal minimum.

The examination of twigs of apple trees undertaken at your suggestion has failed thus far to discover any chemical differences between hardy and non-hardy trees.

On the other hand a remarkably large quantity of soluble food was found to be present in the twigs and long after sap motion must have ceased, This point will be studied further next fall and winter.

The examination of foods for adulteration is still being carried on and the work is being expanded so as to ultimately include all kinds of human food. This investigation is made possible by the funds kindly placed at my disposal for the collection of samples by the Hon. J. H. Calderhead, Commissioner of Agriculture, Labor and Industry.

The usual miscellaneous and routine work has been carried on.

Mr. Cobleigh has been unable, on account of increased College work, to give any assistance whatever in the Station laboratory.

Mr. Burk has given considerable aid, particularly in the routine work.

Yours truly,

F. W. TRAPHAGEN.

Report of the Botanist.

Bozeman, Montana, June 30, 1900.

Prof. S. M. Emery, Director Montana Agricultural Experiment Station :

DEAR SIR:—I herewith submit my report as Botanist of the Station for the year ending this date :

The field-work for the summer of 1899 was mainly devoted to the study of the weeds, the parasitic fungi, the forest and shade trees, the forage plants and grasses, and the alkali plants of the state. Notes as to the distribution and economic importance of the plants in these several groups were made and collections obtained to insure their identification. The data has mainly been collected in the form of card-indexes so as to be readily available in the preparation of bulletins.

There are 78 species of plants which are sufficiently abundant and troublesome in this state as to be called weeds, and of these about one dozen do most of the damage to growing crops. These weeds are very irregular in their distribution over the state, some sections being nearly free from certain troublesome species, while other parts are badly infested. A knowledge of these more dangerous introductions will serve to prevent their spread to other localities yet free from them and means may be found for exterminating them in the regions already occupied, as has largely been done in the case of the Russian thistle.

About 125 species of parasitic fungi have been collected and named and this work will be continued during the present season, but books and exsiccatæ are badly needed for the determination of these groups, many of which are of the highest economic importance. A card index has been made of the species heretofore reported from this state, both of the parasites and of the host plants.

A beginning in the study of the forestry of the state was made this year. Specimens have been collected and notes made of the distribution of the forest trees, as far as possible, and one trip was made to the western part of the state in this work and that connected with weed distribution. Studies in the cottonwoods of the state have been undertaken with the hope of securing more suitable varieties for shade trees, as we are nearly limited to this group for such cultivation in this state. An effort is being made to attempt the introduction of the elm of the eastern United States and it may possibly serve in certain favored localities to take the place of the cottonwoods. A large part of the present summer will probably be devoted to the study of the forest conditions of the state and the relation of climate to the abundance and geographical distribution of the species.

An attempt was made last summer on the Flathead reservation to learn the plants utilized by the Indians for food, medicine and other purposes, as well as those regarded as poisonous, and this work will be continued as opportunity offers in the hope that we may learn more of the possible utilities of our native plants and the part they played in the domestic economy of the native races before the advent of civilization.

A number of articles designed to be of benefit to the agricultural public have been prepared and published in the press of the state. A large number of letters of inquiry about injurious insects have been received and answered. Some of the letters have brought to my notice outbreaks of insects which I have gone personally to investigate.

Last summer also, a test was made in the acclimation of some 26 species of foreign plants, furnished us by the Department of Agriculture, but owing to the lateness of the season and the accidental destruction by stock of most of the crop, definite results were not secured.

There is still pressing need for more room to provide for the natural expansion of this department and a separation of the work of the College from that of the Station. It is also hoped that sufficient funds may be secured to enable the botanist to be in the field the whole summer, as this field-work must furnish the basis for all studies and investigations in this department and the state of Montana is so large and the conditions in its different sections so diverse that it is only by personal inspection that accuracy and efficiency in this work can be attained.

Respectfully,

J. W. Blankinship.

Report of Biologist and Entomologist.

To Director S. M. Emery:

Dear Sir:—During the past year, which was my first year of connection with the Experiment Station, much time has necessarily been spent in getting acquainted with the conditions and needs of this vast state. Particular attention has been given to learning what insects are causing the most injury to agricultural products. It has been found that the worst fruit insects of other parts of the United States have not yet found their way, to any great extent at least, into our orchards. As regards fruit insects, therefore, it becomes a problem of keeping the orchards free rather than one of devising methods for fighting insects already present.

An illustrated bulletin of about sixty pages on "Injurious Insects, Insecticides, Insecticide Apparatus," is now in press. This bulletin is designed to furnish the fruit grower with much needed information on insects in the state and those liable to be introduced and remedies to be employed against them. Future bulletins will be smaller and will treat of more specific subjects.

A great deal of time and thought has been devoted to my duties as Inspector-at-Large to the State Board of Horticulture. The trips in the state in connection with this work have made necessary nearly five thousand miles of travel.

Many notes have been taken which will be of value in my future work. Nine addresses have been given at institutes and before horticultural meetings.

The preparation of a card catalogue indexing important literature of economic insects has been begun and is already of great service. The catalogue now contains nearly five thousand cards. It is purposed to bring this catalogue as rapidly as possible up to date, and then add to it as fast as literature is received. Respectfully,

R. A. COOLEY.

Report of Manager of Poultry Department.

The following brief report of this department is here given in lieu of the longer report prepared by Director S. M. Emery, since much of the latter is included in Bulletin No. 26.

This department acknowledges with thanks the following donations:

1. An incubator. The Cyphers Incubator Co., Wayland, N. Y.
2. Nine settings of eggs of White Wyandottes, Brown Leghorns and Light Brahmas, from Riverside Poultry Co., Toston, Mont., Mrs. S. S. Huntley, manager.

Incubation proved quite successful this season, the first hatch of the Cyphers incubator giving 92% of fertile eggs. In order to increase facilities for breeding stock and to afford room for experimental work a poultry house 14x72 was built at a cost of $475. This building was very carefully designed and possesses all the practical features of an up-to-date poultry building. It is divided into 6 pens 10x12 feet, with a four foot passageway running along rear. Sub-apartments corresponding to pens above serve as a dusting shed. These open toward the south. Walls of the building are double; on either side of the studding is a double layer of lumber with tarred paper between. Six ventilators carry off foul air, and twelve windows, two in each pen, 30x36 inches afford the necessary light. The building was completed for use Jan. 15, 1900.

In February three breeding pens, consisting of six hens and a cockerel each of White Wyandottes, Barred Plymouth Rocks and Brown Leghorns, were purchased from best sources in the east.

In April a brooder house, 14x36 feet, for incubator chicks was constructed at a cost of $65. This house is divided into seven brooder apartments and will accommodate 350 chicks. Walls of this building are single, made of rough lumber, tar-paper, and drop-siding on outside of studding. During March, April and May some experiments were conducted with a view to determine the effect of different ration upon: 1. Egg production. 2. Percentage of fertile eggs and dead germs. 3: Food value of egg. The results furnished some interesting and instructive statistics which will be presented in a bulletin in course of preparation. Respectfully submitted,

HENRY C. GARDINER, M'gr. Poultry Department.

Report of Irrigation Engineer.

Bozeman, Montana, July 30, 1900.

S. M. Emery, Director Montana Experiment Station :

DEAR SIR :—I take pleasure in submitting the following brief report on the work of the Irrigation Department during the past year :

The Executive Board has been considerate enough to free me from part of my duties as instructor to College classes and I have thus been enabled to devote more time to the many sided subject of irrigation.

The irrigation investigations have been conducted under three separate and distinct departments. On account of the earnest efforts of the friends of irrigation among the members of the last legislature an approgriation of $1000 a year for two years was granted for the purpose of collecting additional information regarding the water supply and irrigation interests of this state; all moneys so appropriated were to be expended under the authority and direction of the governing boards and officers of this Experiment Station.

More than a year ago an agreement was made with Professor Elwood Mead, in charge of irrigation investigations for the office of Experiment Stations, United States Department of Agriculture, that I should act as his agent in performing experiments on the duty of water in Montana and collecting such data as would be of value in improving the present methods of distributing and applying water and in devising more suitable laws that would lessen the controversies over water-rights.

About the same time arrangements were also made with Mr. F. H. Newell, chief of the hydrographic division of the United States Geological Survey, that I should have charge of the measurement of the streams of Montana, supervise the labors of the various river observers and prepare a paper for the Geological Survey on the conveyance of water in canals, flumes and pipes.

The results of my experiments and investigations on the duty of water in this State are now being printed with other reports from various western states under the direction of Director True of the office of Experiment Stations, and arrangements nave been made with him to print 6000 extra copies of my report as a bulletin of the Montana Experiment Station for distribution in this state.

My paper of about eighty pages on the conveyance of water is also being printed by the United States Geological Survey and Mr. Newell has kindly given his consent to print 6000 extra copies for distribution in this state as an Experiment Station bulletin.

Respectfully, S. FORTIER,
Irrigation Engineer.

LIST OF BULLETINS

ISSUED BY

Montana Agricultural Experiment Station.

BOZEMAN, March, 1894—July, 1900.

Bulletin No. 1—March, 1894. Organization. Announcements. S. M. Emery.
" No. 2—May, 1894. Smut of Wheat, Oats and Barley. Luther Foster.
" No. 3—June, 1894. Pig Feeding. Luther Foster.
" No. 4—June, 1874. Glanders. W. L. Williams.
" No. 5—February 1, 1895. First Annual Report. S. M. Emery.
" No. 6—June, 1895. Measurement of Water. A. M. Ryon.
" No. 7—June 1, 1895. Small Grains and Potatoes. Luther Foster.
" No. 8—July 1, 1895. Second Annual Report. S. M. Emery. Parasitic Ictero-Hæmaturia of Sheep. W. L. Williams.
" No. 9—April, 1896. Potatoes. Luther Foster.
" No. 10—June, 1896. Small Grains.—Wheat, Oats and Barley. Luther Foster.
" No. 11—June, 1896. Devices for Obtaining a Constant Flow in Laterals with Variable Heads in the Main Canals or Reservoirs. A. M. Ryon.
" No. 12—September, 1896. Third Annual Report. S. M. Emery. The Spaying of Mares. W. L. Williams.
" No. 13—February, 1897. Drinking Water. F. W. Traphagen.
" No. 14—June, 1897. Montana Swine Feeding. Frank Beach.
" No. 15—July, 1897. Larkspur Poisoning of Sheep. E. V. Wilcox.
" No. 16—February, 1898. Fourth Annual Report. S. M. Emery.
" No. 17—April, 1898. The Grain Aphis. E. V. Wilcox. An Army Cutworm. E. V. Wilcox.
" No. 18—June, 1898. The Alkali Soils of Montana. F. W. Traphagen.
" No. 19—October, 1898. The Sugar Beet in Montana. F. W. Traphagen.
" No. 20—August, 1898. Fifth Annual Report. S. M. Emery.
" No. 21—May, 1899. Sheep-Feeding. R. S. Shaw.
" No. 22—June, 1899. The Resistance of Strawberries to Frost. Potato Scab. Treatment of Seed Oats for Smut. Losses caused by the Grain Aphis. Roup of Chickens. The Internal Chicken Mite. Lupines as Plants Poisonous to Stock. Cattle Poisoning by the Tall Larkspur. Poisoning of Stock by the Water Hemlock. Ergotism in Horses. The Poisoning of Cattle by Smutty Oat Hay. List of Plants of Known or Suspected Poisonous Properties which Occur Within the State. Some Native Forage Plants of the State. E. V. Wilcox.
" No. 23—May, 1900. Injurious Fruit Insects. R. A. Cooley.
" No. 24—July, 1899. Sixth Annual Report. S. M. Emery.
" No. 25—April, 1900. Paris Green and London Purple in Montana. F. W. Traphagen.
" No. 26—April, 1900. Poultry Raising. H. C. Gardiner.
" No. 27—April, 1900. Live Stock Feeding Tests. Beef Cattle, Lambs and Swine. R. S. Shaw.
" No. 28—July, 1900. Seventh Annual Report. S. M. Emery.

.....INDEX.....

BULLETINS 1 to 28.

The bulletin numbers appear in black type, larger than the ordinary type in which page numbers are set.

Alfalfa, **21**:10. 11, **24**:120, **28**:13.
Alkali, **18**:21-50, **19**:70.
Alsike, **21**:10.
Analysis; see "Chemical Composition"
Annual Reports, **5**, **8**, **12**, **16**, **20**, **24**, **28**.
Aphis, Apple Plant Louse, **23**:92.
Aphis, Grain, **17**:3, **22**:25.
Aphis, Woolly, of Apple, **23**:89.
Apple, **8**:201, **12**:75. 79, **16**:85, **20**:98, **24**:127, 135, **28**:8.
Aonle Plant Louse, **23**:92.
Apple-tree Borer, Flat-headed, **23**:77.
Apple-tree Borer, Round-headed, **23**:75.
Apricot, **8**:202, **12**:77, **16**:88, **20**:101, **24**:136.
Army Cut-worm, **17**:10-18.
Arsenate of Lead for Spraying, **23**:102.
Arsenite of Lime for spraying, **23**:104.
Bark-bursting of fruit trees, **28**:9.
Bark-louse, Oyster-shell, **23**:85.
Barley, analysis of, **7**:184.
Barley of Gallatin Valley, **20**:112.
Barley, varieties of, **7**:183, **10**:37, 39, **24**:149.
Beet for sugar, **19**:53 90.
Beet-sugar, **19**:54-59.
Blight of Apples and crabs, **20**:103.
Bordeaux Mixture for spraying, **23**:106.
Bulletins, **5**:140, **8**:200, **12**:73, **16**:69, **20**:111, **24**:121, **28**:19.
Buildings; see "Farm Improvements."
Campbell System of soil culture, **24**:146 **28**:11.
Carceag, **8**:212-220.
Catarrh, acute nasal in horses, **4**·94.
Catarrh, chronic nasal in horses, **4**:95.
Catarrhal Fever in horses, **4**:94.
Cattle, feeding, **3**:47, **19**:68, **27**:3-10.
Cattle, Poisoning by Larkspur, **22**:45-47.
Cattle Poisoning by Smutty Oat Hay, **22**:51.
Chemical Composition of
  Alkali, **18**:28-47.
  Barley, **7**:184.
  Bridger Limestone, **19**:89.
  Drinking-water, **13**:3-15.
  Feeding Stuffs, **3**:41-43.
  London Purple, **25**:3-7.
  Potatoes, **7**:186.
  Soil, **7**:175, **19**:64.
  Sugar Beet, **19**:69.
  Wheat, **7**:179, **10**:35.
Cherries, **8**:202, **12**:77, **16**:87, **20**:100, **24**:36, **28**:9.
Chicken Mite, internal, **22**:30.
Chicks, **26**:6.
Cippoletti Measuring Weir, **6**:158.
Clover, **12**:66, **21**-11, **24**:119, 120, **28**:12.
Codling Moth, **23**:64-69.
Corrosive Sublimate for potato scab, **7** 187, **9**:22, **12**:104.
Cows, Feeding of, **3**:48.
Crab-apples, **12**:76, **16**:87, **20**:100, **24** 127, 136, **28**:8.
Crop Statistics, **5**:135, **8**:195, 196, **12**:64 **16**:61. **20**:117, **24**:124, **28**:10, 11.
Culture; see under the several subject
Curculio of Plum, **23**:78.

Currant, 8:202; see also "Small Fruits."
Currant Flies, 23:97.
Cut-worm, army, 17:10-18.
Departments; see under several heads.
Devices for obtaining a constant flow of water in laterals, 11:49 58.
Diagnosis of Glanders in Horses, 4:89-91, 96-105.
Diseases; see under the heads of Cattle, Chickens, Horses, Plants, Sheep and Swine.
Donations, 5:139, 8:199, 12:71, 16:68.
Dormant Trees, 24:32, 28.9.
Drinking Water, analysis and purification, 13:3-15.
Duty of Water, 6:151.
Effects of Alkali upon vegetation, 18:26 28.
Egg Analysis, 26:24.
  Fertility, 26:18, 22.
  Preserving, 26:18.
Epizootic Catarrhal Fever, in horses, 4:94.
Ergotism in horses, 22:49.
Experiment Plats; see 'Rotation Plats.'
Facial Sinuses, disease in horses, 4:95.
Farm Animals, feeding, 3:45-48.
  Buildings and Improvoments, 5:133, 8:200, 12:62, 16:57, 20:94, 95, 24:119, 26:3, 28.13.
  Experiment Station, 1:7-9, 5:132, 8:192.
Farmers' Institutes, 1:14, 5:136, 8:196, 12:68, 16:68, 20:109, 28:4.
Feeding Cattle, 3:47, 19:68, 27:3-10, 28:12.
  Cows, 3:48.
  Farm Animals, 3:45-48.
  Period of, 3:57,58.
  Poultry, 26:7, 20.
  Sheep, 20:18, 21:3-13, 27:11-22, 28:12.
  Swine, 3:35-62, 14:19-34, 27:28-32, 28:12.
  Tables of, 3:36-38.
Fences, 5:134, 8:104, 14:34.
Fertilization of Irrigation Water, 6:150.
Fertilizers, 5:134, 8:194.
Field Peas; see "Pea."
Flat-headed Appletree Borer, 23:77.
Foods, Cooked vs. Uncooked, 3:60.
  for Dairy Cows, 3:48.
    Farm Animals, 3:47.
    Sheep, 21:7, 27:12-14.
    Steers, 27:5.
  Preparation of, 3:58.
  Wet vs. Dry, 3:59.
Forage Plants, native, 8:206, 22:54.
Forestry, 20:96 98.
Frost and Freezing, affecting fruit trees, 16:79-82, 22:17, 28:9.
Frost Resistance of Strawberries, 22:17-21.
Fruit trees, Bark bursting of, 28:9.
  Insect Enemies of, 23:64-102
Fruit-worm of the Gooseberry, 23:62.
Gaging Streams, 24:125.
Glanders, as Affected by Age, 4:87.
    Breed, 4:87.
    Climate, 4:82-85
    Food, 4:87.
    Labor, 4:86.
    Stabling, 4:85.
  Causes of, 4:70.
  Diagnosis, 4:89-91.
  Pathology, 4:70-74.
  Prevalence among Montana horses, 4:107.
  Symptoms of, 4:74-82.
Gooseberry Fruit-worm, 23:72.
Grain Aphis, 17:3, 22:25.
Grain Tests; see "Variety Tests."
Grass and Weed Collection, 8:206.
Greenhouse, 20:95, 24:116.
Ground Water, 18:23.
Hatch Act, 1:9-11.
Hellebore for spraying, 23:115.
Horse, diseases of, 4:67-113, 22:41,49.
Horticulture, 8:202, 12:73, 16.69, 24:125, 28:6.
Improvements at the Station; see "Farm Improvements."
Incubators, Incubation, 26:5.
Incubator Oils, 26:17.

Insects Injurious to Fruit:trees, 23:64-102.
Insecticides, 23:102.
Insecticide Apparatus, 23:108.
Inventory of Station Property, 12:72.
Irrigation, 6:149-170, 11:49-58, 16:76, 17:13, 18:23-27, 19:60,20:115,28:18.
Kerosene Emulsion, 23:105.
Ladoga Wheat, 10:36.
Larkspur Poisoning of Cattle, 22:45-47.
Sheep, 15:37-51.
Loco. 22:38, 56.
London Purple, analysis of, 25:3-7.
for spraying, 23:103.
Lupine poisonous to stock, 22:37-45.
used for forage, 22:38,41.
Manufacture of Beet Sugar, 19:59,89.
Measurement of Irrigation Water, 6: 149-170, 11:49-58.
Mite, Internal of Chickens, 22:30.
Montana Foods for stock, 3:50.
Morrill Act, 1:12, 13.
Nasal Gleet in Horses, 4:91.
Newspaper Exchange List; see "Press List."
Nutrients for Farm Animals, 3:45-48.
Oat, Smut of, 10:43, 44, 22:51.
varieties data, 7:180-182, 10:37, 38, 24:148.
Orchard, 8:200-202, 12:73-82, 16:82-89, 20:98-104, 24:125-141, 28:8-10.
Organization of the Station, 1:3-16, 5: 132.
Ornamental Shrub Culture, 28:6.
Oyster-shell Bark-louse, 23:85.
Parasitic Ictero-Hæmaturia of Sheep, 8:212-220.
Paris Green, Analysis of, 25:3 7.
for spraying, 23:108.
Pea, field, for forage, 8:195, 12:65, 16:62.
Pears, 12:76, 16:87, 20:100, 24:136, 28:9.
Psylla of, 23:93.
Pear Slug, 23:73.
Pear-leaf Blister-mite, 23:100.
Period of Feeding, 3:57, 58.
Pig-feeding; see "Swine Feeding."
Pink-eye in horses, 4:93.
Plant Diseases, 2:19-32, 7:187, 8:205, 206, 10:40-45, 20:103, 22:22-26.
Injuries caused by Insects, 23: 64-102.
Plants, poisonous, 15:37-51, 22:37-53.
Plant-bug, Tarnished, 23:96.
Plat Culture; see "Rotation Plats."
Plum, 8:201, 12:78, 16:88, 20:101, 24: 136, 28:9.
Plum Curculio, 23:78.
Poisoning by Plants of Cattle, 22:45-51.
Horses. 22:49.
Sheep. 15:37-51.
Poisonous Plants; see "Plants Poisonous" above.
Potato, 7:185-187, 8:204, 9:3-24, 22:22.
Analysis of, 7:186.
Cultivation, 9:4-10.
Planting, 8:204, 9:11, 14:22.
Scab, 7:187, 8:206, 9:22 24, 12: 104, 22:22.
Varieties data, 7:185, 9:12-13.
Poultry, 26:3-26, 28:17.
Breeding, 26:8.
Breeds, 26:4-9.
Brooders, 26:6, 14, 15.
Buildings, 26:10-14.
Diseases of, 22:27-36.
Feeding, 26:7-20.
Pure-bred, 26:9.
Preserving Eggs, 26:18.
Preparing food for stock, 3:58-60.
Press, Communications to, 5:137.
Press list, 5:137, 8:197, 12:69, 16:65, 20:109, 24:122, 28:5.
Prune, 8:201, 12:77, 16:88, 20:101, 24:136.
Psylla of Pear, 23:93.
Quantity of seed per acre, 10:30.
Remedies for Alkali, 18:25.
Army Cut-worm, 17:13.
Glanders, 4:108-118.
Grain Aphis, 17:7.
Insects Injurious to fruit trees, 23:102-114.

Remedies for Poisonous Plants, **15**:43, **22**:47-50.
  Potato Scab, **7**:187, **8**:206, **9**:23, **12**:104, **22**:23.
  Roup in chickens, **22**:28.
  Smut, **2**:24-30, **8**:205, **12**:105, **22**:24.
  of Barley, **2**:23.
   Oats, **2**:27, **10**:44, **22**:24.
   Wheat, **10**:40.
Report of Agriculturist, **5**:141, **8**:202, **16**:90, **20**,124, **24**:145, **28**:10.
  Biologist, **5**:141, **16**:89, **20**:121. **28**:16.
  Botanist, **8**:202, **20**:119, **24**:151, **28**:14.
  Chemist, **5**:142, **8**:206, **12**:94, **16**:92,**20**:122,**24**:144,**28**:13.
  Director, **5**:182, **8**:192, **12**:62 **16**:57, **20**:94, **24**:188, **28**:4.
  Horticulturist, **8**:201, **12**:73, **16**:69, **20**:98, **24**:125, **28**.6.
  Irrigation Engineer, **8**:208, **28**:18.
  Poultry Department, **28**:17.
  Treasurer of the Board, **5**:131, **8**:191. **12**:61, **16**.55, **20**:93, **24**:117, **28**:3.
  Veterinarian, **5**:144, **8**:212.
  Zoologist and Entomologist, **24**:150, **28**:16.
Resin-wash for spraying, **23**:106.
Rotation Plats, **5**:134, **8**:194, **12**:63, **16**:59, **20**:111, **24**:123, **28**:11.
  Tests; see the preceding.
Round-headed Apple-tree Borer, **23**:75.
Roup of Chickens, **22**:27, 30-36.
Samples of Drinking Water, **13**:15.
San Jose Scale, **23**:79.
Scab of the Potato; see "Potato Scab."
Scurfy Bark-louse, **23**:88.
Seeding Potatoes, **8**:204, **9**:11.
  Small Grains, **10**:28-31.
Shade trees. **20**:96-98.
Sheep, Diseases of, **8**:212-220.
  Feeding, **21**.3 13, **27**:11-22.
  Poisoning by plants, **15**:37-51, **22**:39, 40.
Shrubs, Ornamental, **28**:6.
Site of Station, **1**:6-9.
Slug of Pear, **23**:78.
Small Fruits, **8**:202, **16**:85.
  Grains, **7**:178, **10**:27-46.
Smut, **2**:19-32, **8**:205, **10**:40. **12**:105, **22**:24, 51.
  of Barley, **2**:23, **10**:43.
   Oats, **10**:43, **22**:24.
   Wheat, **2**:22, **10**:40.
  Cause of, **2**:21.
  Damage by. **2**:19-21.
  Poisoning of cattle by, **22**:51.
Smutty oat hay, **22**:51.
Soils, **18**:21-50, **19**:63.
Spaying of mares, **12**:96-103.
Station Buildings and Improvements; see "Farm Buildings."
Station Staff, **1**:6, **5**:132, **8**:192, **12**:62, **16**:57, **20**:94, **24**:118, **28**:2.
Steer feeding, **27**:3-10.
Strangles in horses, **4**:92.
Strawberries, **8**:202, **12**:82-93, **16**:69-77, **20**:104-109, **22**:17, **24**:141-144.
  Frost resistance of, **22**:17-21.
Stream Gaging, **24**:125.
Stringfellow Method of Planting Fruit Trees, **24**:138, **28**:10.
Sugar Beet, **19**:53-90.
  Consumption, **19**:57.
Summer Fallow, **10**:27, **12**:67, 68, **16**:59, **24**:120, **28**:11.
Swine Feeding, **3**: 35 62, **8**:205, **14**:19-34, **27**:23-32.
  Pasture Fences, **14**: 34.
Tables of Feeding, **8**:36-48.
Tarnished Plant-bug. **23**:96.
Teeth, diseased in horses, **4**:95.
Tent Caterpillar. **23**:70-71.
Terminal Buds, immaturity of, **28**:9.
Trees for shade and ornament,**20**:96-98.
Tumors in nostrils of horses, **4**:96.
Underdrainage as a remedy for alkali, **18**:25.
Variety Tests, Barley, **7**:183, **10**:37,39, **24**:149, **28**:10.

    Oats, **7**:180-182, **10**:37-38, **24**:148, **28**:10.
    Strawberries; see "Strawberries."
    Sugar Beets, **19**:72-84.
    Wheat, **7**:176-179, **10**:31-37, **24**:147, **28**:10.
Water, Analysis of, **13**:3-15.
  Duty of, **6**:151.
  Measurement, **6**:149-170.
  Meters, **6**:156.
Water Hemlock, poisoning by, **22**:48.
Weeds, **8**:206, **12**:63.
Weir Measurement, **6**:156-165.
Whale Oil Soap for Spraying, **23**:105.
Wheat, Analysis, **7**:179.
  Spring, **10**:39.
  Smut, **10**:40-43.
  Varieties data, **7**:176-179, **24**:147.
Winter-killing of fruit trees, **28**:9.
Woolly Aphis of the Apple, **23**:89.

30.679
M92b

UNIV. OF MICH.
JAN 18 1900

BULLETIN NO. 29.

MONTANA AGRICULTURAL

EXPERIMENT STATION

-- OF --

THE MONTANA COLLEGE OF AGRICULTURE.

THE QUANTITY OF WATER USED IN IRRIGATION

AND

THE SEEPAGE LOSS FROM CANALS.

BOZEMAN, MONTANA, NOVEMBER, 1900.

BOZEMAN CHRONICLE,
Bozeman, Montana,
1900.

MONTANA AGRICULTURAL
EXPERIMENT STATION.

EXECUTIVE BOARD.

Lester S. Willson, President	Bozeman
Peter Koch, Secretary and Treasurer	Bozeman
Walter S. Hartman	Bozeman
John M. Robinson	Bozeman
Joseph Kountz	Bozeman

EXPERIMENT STATION STAFF.

S. Fortier, Ma. E	Director and Irrigation Engineer
F. W. Traphagen, Ph. D., F. C. S	Chemist
Robt. S. Shaw, B. S. A	Agriculturist
J. W. Blankinship, Ph. D	Botanist
R. A. Cooley, B. Sc	Entomologist

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director,

Montana Experiment Station,
Bozeman, Mont.

NOTICE—The bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Experiment Station.

Bulletin No. 29. - - - November, 1900.

THE QUANTITY OF WATER USED IN IRRIGATION AND THE SEEPAGE LOSS FROM CANALS.

S. FORTIER, DIRECTOR.

INTRODUCTION.

In the spring of 1899 the Montana Experiment Station, through its Executive Board, agreed to co-operate with Dr. True, Director of the Office of Experiment Stations, in carrying on irrigation investigations in the use of water in the state of Montana. The general outline of the work was planned and its subsequent supervision was ably performed by Prof. Elwood Mead, expert-in-charge of irrigation investigations.

Prof. Mead also outlined and supervised similar investigations in nine other western states and territories, the results of which have been recently published as Bulletin No. 86 of the Office of Experiment Stations.

Through the kindness of Dr. True this station obtained at a nominal rate 6,000 copies of the report of the Montana investigations for 1899, in separate form. These have already been distributed to the farmers of this State.

In the spring of 1900 a similar agreement was entered into between the same parties. A report containing the results of the experiments made during the season of 1900 was recently forwarded to Prof. Mead, and the same results, in a slightly modified form, are herein presented, in the hope that they may contain something of interest and value to the agriculturists of Montana.

THE PROPER QUANTITY OF WATER TO APPLY.

The investigations that were carried on during the summer of 1899 were planned with the view to ascertaining the actual quantities of water used by irrigators, the percentage of loss in their canals, the method of distribution, and the principal conditions which affect the duty of water. At the beginning of the season just closed similar lines of work were taken up, the only difference from the preceding year being in more extended operations throughout different parts of the state. In addition to these investigations it was thought desirable to institute a second series of experiments for the purpose of determining the proper amount of water to apply to growing crops and the proper time to irrigate. It is intended that this series will extend through a period of at least five years, during which time the staple crops of Montana can be experimented on with the object of finding out how much water is necessary to produce the most valuable yields and the right time to apply it. It will be noticed that this series is supplementary to what has been carried on in former years. It was necessary first to ascertain what use was made of irrigating water, and with this information as a basis, to conduct experiments along more scientific lines in trying to demonstrate to the irrigator the mistakes he was making in using either too little or too much water, or in irrigating at the wrong time.

Last spring a distributing flume (Fig. 1) was built in such a manner that it could be readily taken apart and placed on some other location if desired. The sides and bottom consisted of 1½-inch planks, held in place by yokes placed four feet apart. This flume was connected with a weir box at its upper end, and in the weir box there was an adjustable wasteway, by which the water admitted into the flume could be regulated. By this device the water could be not only measured as it passed into the distributing flume, but diminished or increased to any desired amount up to the total flow of the lateral. Along the right side of this flume plats to the number of sixteen were laid off. Each plat was 50 feet wide and 100 feet long, and was separated from bordering plats by strips of bare ground 15 feet wide. The object of having a strip of bare ground between every two plats was to prevent the passage of water, either by seepage or otherwise, from one plat to another. On the 21st of May, 1900, all the plats were seeded to oats at the rate of two bushels of seed per acre. Nine days later the percentage by weight of moisture contained in the soil of each plat was determined by Mr. Edmund Burk, under the supervision of the chemist, Dr. Traphagen. A sample of soil extending from the surface to a depth of two feet was obtained from the center of each plat by means of an inch and a half auger. This cylinder of soil, 1½ inches in diameter and 24 inches in length, was placed in a Mason's jar, and the lid screwed tightly down to prevent evaporation. The following are the results found after evaporating the entire moisture content and comparing the loss in weight thus effected with the original weight of the sample:

Sample from Plat No.	1	18.30	per cent moisture.
" " " "	2	19.97	" " "
" " " "	3	17.74	" " "
" " " "	4	18.05	" " "
" " " "	5	18.94	" " "
" " " "	6	18.08	" " "
" " " "	7	17.29	" " "
" " " "	8	18.65	" " "
" " " "	9	20.26	" " "
" " " "	10	19.03	" " "
" " " "	11	20.95	" " "
" " " "	12	20.46	" " "
" " " "	13	18.08	" " "
" " " "	14	17.81	" " "
" " " "	15	19.30	" " "
" " " "	16	20.30	" " "

These results show that the soil of the plats to a depth of two feet was composed of nearly one-fifth by weight of water, and that the amount of moisture in each was practically equal.

On June 25 the first irrigation was begun. A measured quantity of water was allowed to flow through the flume to each plat, which was irrigated separately. Small galvanized-iron slides moving vertically in grooves and placed over 1¾-inch openings, controlled the flow from the distributing flume to each plat. The water through these openings (Figs. 2 and 3), which were spaced four feet apart, was allowed to flow on the plat until the earth became so moist that part of the water began to escape. It was found that a depth of four inches over the surface was as much as could be applied without waste at any one time. Had the plats been arranged in terraces with a low embankment around each, it would have been possible to have applied a larger quantity of water at one time and thus to have reduced the number of irrigations. This mode of irrigating is not, however, practiced in Montana, and it was deemed important that the experiments conform as closely as practicable to the common methods of irrigating. In the case of a large field, it is possible to allow the water to flow slowly over the surface until the ground is wet for a foot or more in depth. With the small plats, and using the flooding method, the water could not flow long over the surface without waste, and a less quantity of water had to be used at more frequent intervals. The quantity of water applied to each plat when measured in depth over the surface as well as the corresponding dates are given in the accompanying table.

Plat No.	No. of Irrigations.	Date.	Depth Applied.	Remarks.
			Inches.	
1	Not irrigated.			Received some moisture from adjacent ditch and a leaky flume.
2	First irrigation.	June 25	2	Oat crop from six to nine inches high.
3	First "	June 25	4	Same as No. 2.
	Second "	July 16	4	Height of grain 23 ins., 8 per cent headed out.
4	First "	June 25	5	Same as No. 2.
	Second "	July 16	4	Four per cent headed out.
5	First "	June 26	4	Same as No. 2.
	Second "	July 16	4	Three per cent headed out.
	Third "	July 26	4	Height of grain 37 inches.
6	First "	June 26	4	Same as No 2.
	Second "	July 6	4	Grain 16½ inches high.
	Third "	July 16	4	Grain 23 inches high.
	Fourth "	July 27	4	Grain 41 inches high.
7	First "	June 26	4	Same as No. 2.
	Second "	July 6	4	
	Third "	July 17	4	Two per cent headed out.
	Fourth "	July 27	4	
	Fifth "	Aug. 6	4	Grain 55 inches high.
8	First "	June 26	4	Same as No. 2.
	Second "	July 6	4	Same as No 6.
	Third "	July 16	4	Three per cent headed out.
	Fourth "	July 27	4	
	Fifth "	Aug. 6	4	
	Sixth "	Aug. 15	4	

The following table gives the yields per plat in grain and straw, as well as the corresponding yields per acre, allowing 34 pounds of oats per bushel.

No. of Plat.	Grain per Plat. Pounds.	Straw per Plat, Pounds.	Total Pounds.	Yield per acre.	
				Grain Bushels.	Straw. Pounds,
1.	180	190	370	46.122	1655.28
2.	241	284	525	61.729	2345.408
3.	266	324	590	68.158	2822 688
4.	287	343	630	73.539	2988 216
5.	292	353	645	74 825	3075.336
6.	305	390	695	78 151	3397 68
7.	303	377	680	77.639	3284.424
8.	326	369	695	83.532	3214.728

In comparing the depth of water applied to each plat as expressed in inches with the yield of grain, a glance at the table given below will show the close relation between the amount of water and the yield. These results, however, may not represent the average of a number of years. The past season was extremely dry, and the soil moisture tests showed that the greater part of each watering was soon evaporated. In view of these exceptional conditions, no attempt will here be made to draw conclusions from the results obtained from one season's operations.

No. of Plat.	Depth of Water. Inches.	Yield per Acre.	
		Grain. Bushels.	Straw, Pounds.
1.	0	46.12	1655.28
2.	2	61.73	2345.41
3.	8	68.16	2822 69
4.	9	73.54	2988.22
5.	12	74 83	3075 34
6.	16	78.15	3397 68
7.	20	77 64	3284.42
8.	24	83.53	3214.73

DUTY OF WATER IN GALLATIN VALLEY.

EXPERIMENT NO. 1.

The duty of water varies greatly on the same field in different seasons and for different crops. On a field of clover belonging to the Hon. James E. Martin, and situated in the southeastern part of Gallatin valley, the quantity of water applied during the past season was nearly two feet over the surface in two irrigations, while the same field when seeded to barley received, in 1899, a trifle less than one foot in one irrigation.

The field sloped from the south to the north at the rate of about 80 feet to the mile, and also to the east to a less extent. The field laterals were parallel and ran diagonally through the field on a grade of about 1.5 inches to the rod. The distance between the laterals ranged from 56 to 93 feet and averaged 69 feet. The soil consists of a clay loam, with a porous stratum of gravel wash beneath. This field was summer-fallowed in 1897, and seeded to barley and oats in 1898, the yield being 73 bushels per acre of barley and 50 bushels of oats. It was seeded down to red clover with barley as nurse crop in 1899, and produced two crops of clover during the season just closed.

Duty of water on clover, as shown by experiment No. 1.

	First Irrigation.	Second Irrigation.	Total.
Date of irrigation	June 14-22	July 28-Aug. 17	
Duration of irrigation ... hours	286	478	764.
Area irrigated ... acres	66.39	66.39	66.39
Water used ... *acre-feet	87.32	46.75	134.07
Average depth of water applied ... feet	1.31	0.67	1.98
Rain-fall, May 1st to September 10th ... feet	....	....	44
Total depth of water received during growth ... feet	....	....	2.42
Number of irrigators	2	2	
Average head of water used ... †cu. ft. per sec	3.955	1.13	....
Average distance between field laterals ... feet	....	....	69.

*An acre-foot of water is the quantity required to cover an acre, one foot in depth. Since an acre contains 43,560 square feet, an acre-foot of water would be equivalent to 43,560 cubic feet.

†To change cubic feet per second into Montana miner's inches multiply the former by 40. Thus, 3.955 cubic feet per second equals 158.2 miner's inches.

EXPERIMENT NO. 2.

This test was made on a field of barley 4.14 acres in extent, located near the southwest corner of the Experiment Station farm. This field has been cropped continuously since 1893. It produced potatoes in 1894, barley in 1895, oats in 1896, peas in

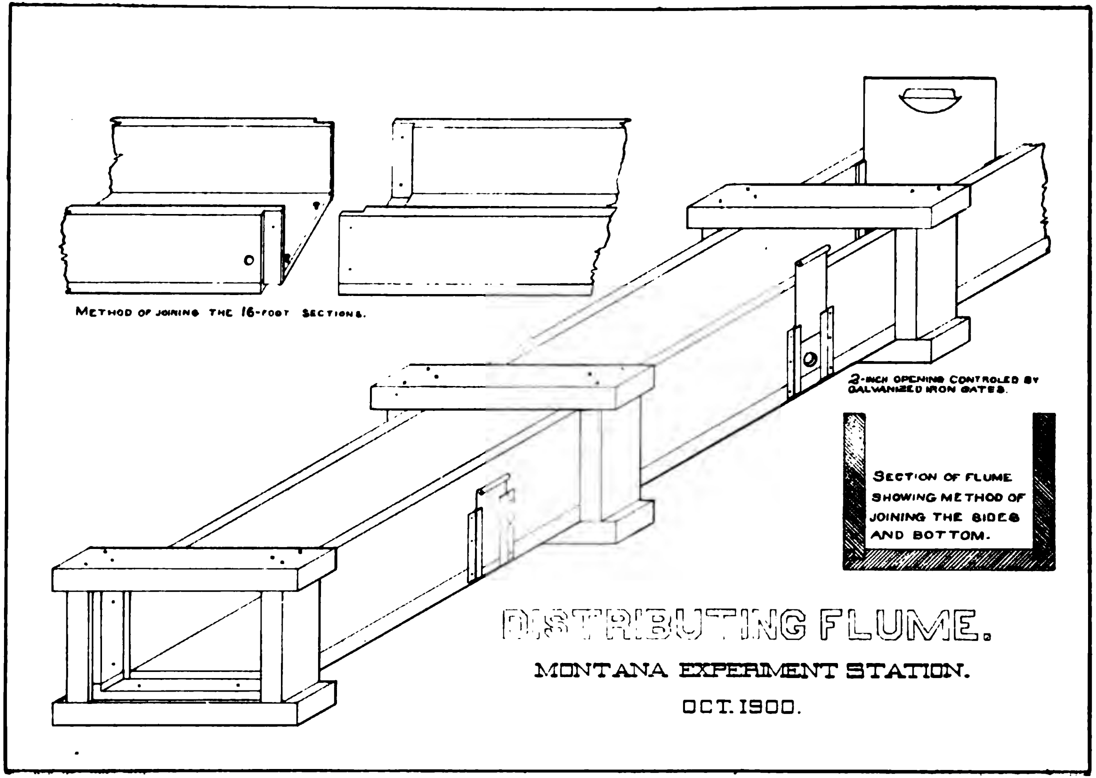

Method of joining the 16-foot sections.
2-inch opening controled by galvanized iron gates.
Section of flume showing method of joining the sides and bottom.
DISTRIBUTING FLUME.
MONTANA EXPERIMENT STATION.
OCT. 1900.

FIG. 1.—DISTRIBUTING FLUME ON EXPERIMENT STATION FARM.

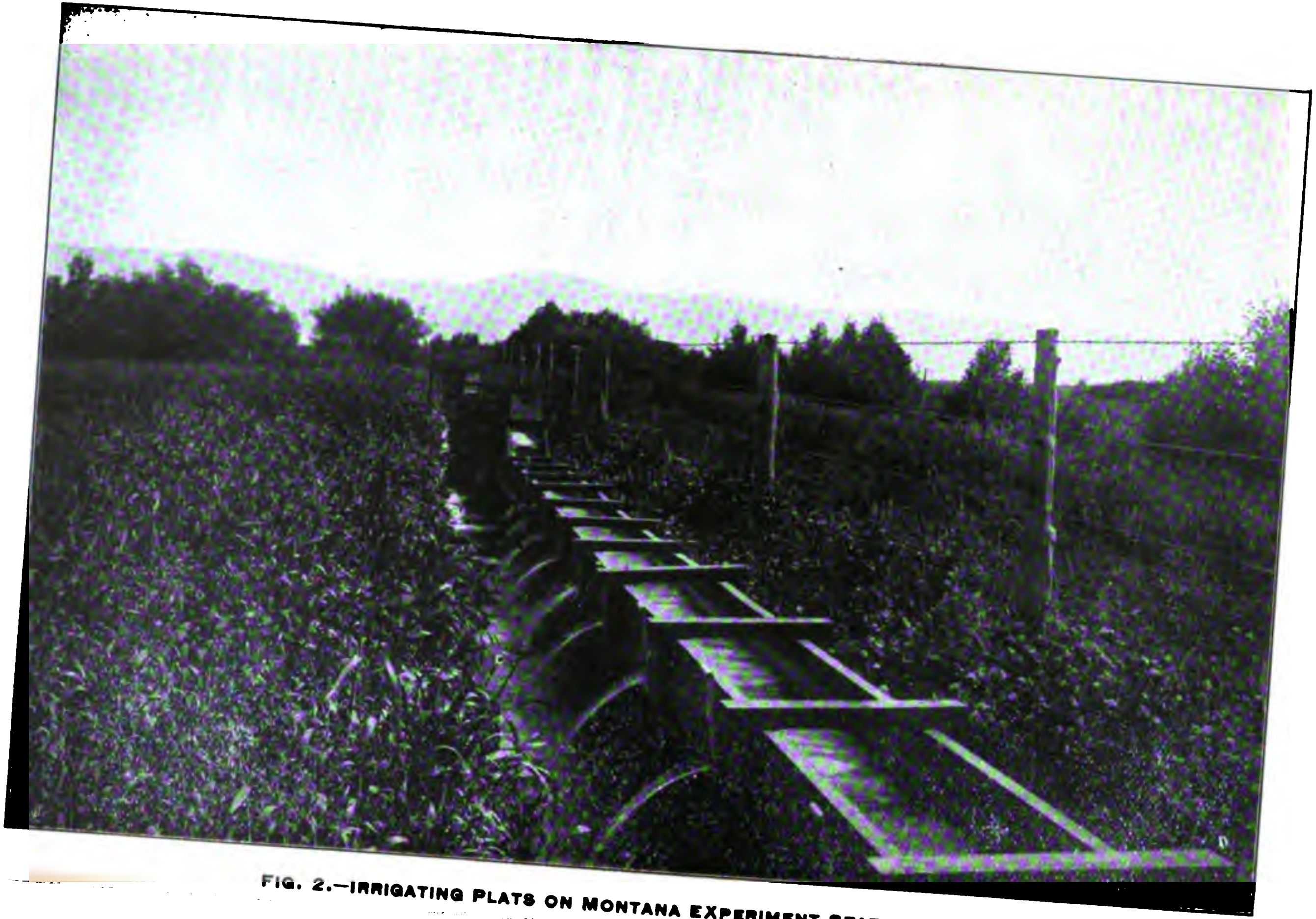


FIG. 2.—IRRIGATING PLATS ON MONTANA EXPERIMENT STATION FARM

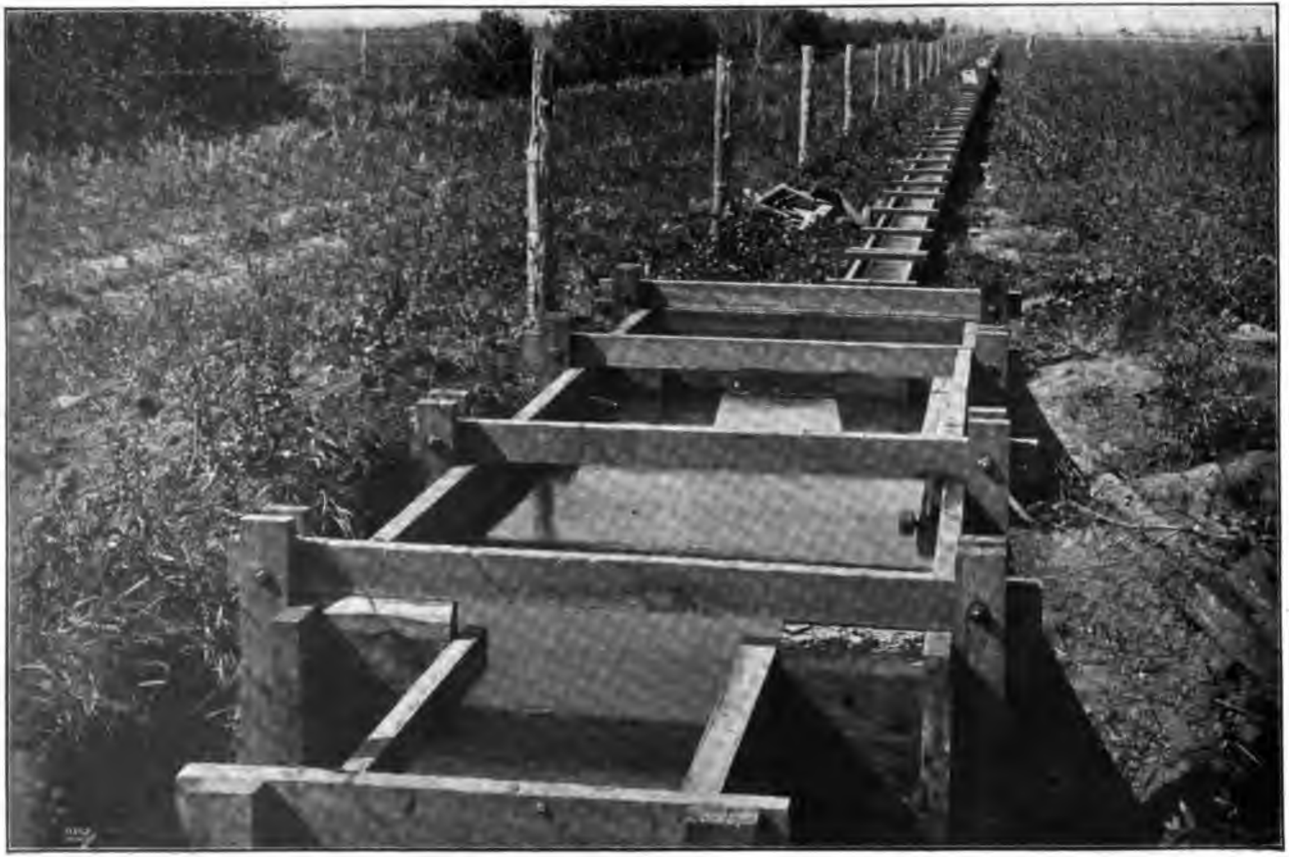


FIG. 3.—MEASURING BOX AND FLUME ON STATION FARM.

1897, barley in 1898, peas in 1899, and barley in 1900. The barley was sown April 20, 1900, irrigated for the first time June 12 and 13, irrigated a second time July 1, and harvested August 17. The yield from the field was 200.8 bushels, or 46.5 bushels per acre.

Duty of water on barley, as shown by experiment No. 2.

	First Irrigation.	Second Irrigation.	Total.
Date of irrigation	June 12-13	June 29-July 1	
Duration of irrigation, hours	25.5	38	62.5
Area irrigated, acres	4.14	4 14	4.14
Water used, acre-feet	3.30	2.91	6.21
Average depth of water applied, feet	.797	.702	1.499
Rainfall, feet			.28
Total depth of water received during growth, feet			1.78
Number of irrigators	2.	2	
Average head of water used, cu. ft. per sec.	1.567	.9235	
Average distance between field laterals, feet			85

EXPERIMENT NO. 3.

A test was made in 1899 on a field of oats belonging to Mr. J. L. Patterson, county commissioner of Gallatin county. Last spring Mr. Patterson again seeded the same field to oats, and the quantity of water used was measured over the same weirs that were built the year previous.

The results as given in the accompanying table indicate that 15.08 acre-feet of water were applied at the first irrigation, and 5.44 acre-feet at the second. The latter, however, was incomplete, in that only about two-fifths of the area of the field was irrigated.

Duty of water on oats, as shown by experiment No. 3.

	First Irrigation.	Second Irrigation.	Total.
Date of irrigation	June 18-21	July 23-29	
Duration of irrigation ... hours	80.25	147	227.25
Area irrigated ... acres	25.09	*25.09	25.09
Water used ... acre-feet	15.06	5.44	20.52
Average depth of water applied ... feet	.62	.02	.64
Rain-fall ... feet	...	...	.39
Total depth of water received during growth ... feet	...	...	1.03
Number of irrigators	1	1	
Average head of water used ... cu. ft. per sec	2.35	.45	2.80
Average distance between field laterals ... feet	...	...	85

*N. B. Only partly irrigated.

EXPERIMENT NO. 4.

For the past four years a regular rotation of crops has been conducted on a tract of land 1,227 feet long and 218 feet wide, on the Experiment Station farm. This tract is divided lengthwise into six equal plats of one acre each, having a strip of bare ground three feet wide between each. The order of the rotation is barley, clover, wheat, peas, oats, and sugar beets.

During the season just closed three separate tests were made on these acre plats. The clover and wheat were irrigated together, as were also the peas and oats, and the remaining test was made on the acre of barley. The soil is of more than average fertility, consisting of vegetable loam, clay loam, clay marl, with an unknown depth of gravel and cobble rock at a depth of about six feet from the surface.

The wheat was seeded May 4, cut August 28, and yielded 38.33 bushels on the acre plat. The clover was seeded May 7, without a nurse crop, cut August 17, and yielded 3,170 pounds of cured hay. The following table gives the results obtained from the wheat and clover.

Duty of water on one acre wheat and one acre clover, as shown by experiment No. 4.

	First Irrigation.	Second Irrigation.	Total.
Date of irrigation	June 18	July 11-12	
Duration of irrigation ... hours	6	7.58	13.58
Area irrigated ... acres	2	2	2
Water used ... acre-feet	.66	.88	1.54
Average depth of water applied ... feet	.33	.44	.77
Rain-fall, May 5th to August 20th ... feet			.30
Total depth of water received during growth ... feet			1.07
Number of irrigators	2	2	
Average head of water ... cu. ft. per sec	1.40	1.40	
Average distance between field laterals ... feet			36

EXPERIMENT NO. 5.

This experiment was made on the peas and oats of the rotation plats. The peas were seeded May 5, cut September 25, and yielded 1,330 pounds. The oats were seeded May 4, cut August 15, and yielded 75.58 bushels per acre plat.

The following table contains the data pertaining to this experiment:

Duty of water on one acre of oats and one acre of peas, as shown by experiment No. 5.

	First Irrigation.	Second Irrigation.	Total.
Date of irrigation	June 18	July 11	
Duration of irrigation ... hours	4.83	5	9.83
Area irrigated ... acres	2	2	2
Water used ... acre-feet	.55	.57	1.13
Average depth of water applied ... feet	.28	.28	.56
Rain-fall, May 4th to August 25th ... feet			.39
Total depth of water received during growth ... feet			.95
Number of irrigators	2	2	
Average head of water used ... cu. ft. per sec	1.38	1.37	
Average distance between field laterals ... feet			36

EXPERIMENT NO. 6.

This experiment was made on the barley of the rotation plats.

This acre was seeded to barley May 5, cut August 25, and yielded 87.29 bushels.

Duty of water on barley as shown by experiment No. 6.

	First Irrigation.	Second Irrigation.	Total.
Date of irrigation	June 19	July 12	
Duration of irrigation...hours	6.71	2.95	9.66
Area irrigated...acres	1	1	1
Water used...acre-feet	.66	.26	91
Average depth of water applied...feet	.66	.51	1.17
Rain-fall, May 5th to August 25th...feet			28
Total depth of water received during growth...feet			1.45
Number of irrigators	2	2	
Average head of water used...cu. ft. per sec	1.18	1.58	
Average distance between field laterals...feet			36

EXPERIMENT NO. 7.

The quantity of water used on an oat field located at the southwest corner of the Experiment Station farm was also determined. The field slopes to the north at the rate of about 90 feet to the mile and also to the east to a like degree.

The oats were sowed May 2, irrigated about the middle of June and also at the end of the first week in July, and harvested August 28. The total yield on the field of 8.51 acres was 635.5 bushels of 34 pounds, or at the rate of 74.67 bushels per acre, and the selling price at this writing (November 10) is 87 cents per 100 pounds. This field has been cropped for eight years. It was seeded to oats in 1893, peas in 1894, and barley in 1895. It was in clover for three years, from 1896 to 1898 inclusive. Last year it was seeded to wheat and barley, the wheat yielding, on an average, 57.89 bushels per acre, and the barley 45 bushels. The results of the two irrigations are given in the following table:

Duty of water on oats, as shown by experiment No. 7.

	First Irrigation.	Second Irrigation.	Total.
Date of irrigation	June 15-17	July 6-7	
Duration of irrigation ... hours..	45.5	29.33	70.93
Area irrigated ... acres..	8.51	8.51	8.51
Water used ... acre-feet..	5.98	4.81	10.79
Average depth of water applied ... feet..	.83	.57	1.39
Rain-fall, May 2nd to August 28th ... feet..	...	...	.40
Total depth of water received during growth. feet..	...	...	1.79
Number of irrigators	2	2	
Average head of water used ... cu. ft. per sec..	1.74	1.98	
Average distance between field laterals ... feet..	...	...	90

EXPERIMENT NO. 8.

This test was made on a field of barley containing 4.52 acres, located on the Experiment Station farm. This field prior to 1897 produced little but weeds. It was seeded to barley in that year, and to peas in 1898. Potatoes were planted in 1899, and the crop of barley grown the past season was sowed April 21, cut August 16, and produced 14,880 pounds, or at the rate of 68.59 bushels per acre. The grain was sold for 87 cents per 100 pounds.

Duty of water on barley as shown by experiment No. 8.

	First Irrigation.	Second Irrigation.	Total
Date of irrigation	June 13-14	July 1-2	
Duration of irrigation ... hours..	24.5	30	54.5
Area irrigated ... acres..	4.52	4.52	4.52
Water used ... acre-feet..	4.42	4.43	8.85
Average depth of water applied ... feet..	.98	.98	1.96
Rain-fall ... feet..	...	...	.42
Total depth of water received during growth. feet..	...	...	2.38
Number of irrigators	2	2	
Average head of water used ... cu. ft. per sec..	2.19	1.79	
Average distance between field laterals ... feet..		...	75

EXPERIMENT NO. 9.

This experiment was made on a field of clover situated on the south side of the Experiment Station farm, containing 7.26 acres.

This field has been cropped continuously since the establishment of the Experiment Station farm in 1893. Last year it was seeded to oats and red clover, and it produced during the past season two heavy crops of clover hay. The first crop was cut and stacked from July 1 to 15, and yielded 19 tons and 15 pounds. The second crop was cut and stacked from September 1 to 15, and yielded 17 tons and 930 pounds, or a total of over 5 tons per acre. The price of clover hay in the stack is from $5.00 to $6.00 per ton. The quantity of water applied at four irrigations was 2.7 feet. Compared with the results obtained from the other fields, this would seem to be an excessive amount. There was, however, but a small percentage wasted, and it is questionable if a less amount of water would have produced as great a yield.

Duty of water on clover, as shown by experiment No. 9.

	First Irrigation.	Second Irrigation.	Third Irrigation.	Fourth Irrigation.	Total.
Date of irrigation	June 4-5	July 3-5	July 19-21	August 1-4	
Duration of irrigation ....hours..	26	50.25	27.5	67	170.75
Area irrigated ....acres..	7.26	7.26	7.26	7.26	7.26
Water used ....acre-feet..	4.21	6.61	4.49	4.31	19.62
Average depth applied ....feet..	.58	.91	.62	.59	2.70
Rainfall, May 1st to Sept. 10th...feet..					.44
Total depth of water received during growth ....feet..					3.14
Number of irrigators	2	2	2	2	
Aver. head water used..cu. ft per sec..	1.96	1.59	1.97	.78	
Aver. distance between field laterals ....feet..					76

EXPERIMENT NO. 10.

During the past season a test was again made on the clover field situated in the southeast corner of the Experiment Station farm, and described in the report for 1899 as Experiment No. 1. This season the field was increased by the addition of another small clover field. The quantities of water applied at each irrigation were only slightly in excess of those of last year, but owing to the long dry season, the date of the first watering was 10 days earlier, in consequence of which three irrigations were necessary, and the total depth of water applied was 1.79 feet, an increase of 0.77 feet over that of last year.

The results of the experiment are given in the following table:

Duty of water on clover, as shown by experiment No. 10.

	First Irrigation.	Second Irrigation.	Third Irrigation.	Total.
Date of irrigation	June 5-7 " 8-11	July 13-16 " 20-24	July 26-28 Aug. 8-14	
Duration of irrigation ... hours	116.42	96.32	63.67	276.41
Area irrigated ... acres	35.9	35.9	85.9	35.9
Water used ... acre-feet	21.85	25.50	16.65	64
Average depth of water applied ... feet	.61	.71	.47	1.79
Rain-fall, May 1st to September 10th ... feet	....	....	....	.44
Total depth of water rec'd during growth ... feet	....	....	....	2.22
Number of irrigators	2	2	2	....
Average head of water used ... cu ft. per sec	2.27	2.65	1.75	
Average distance between field laterals ... feet	....	....	....	80

THE DUTY OF WATER IN MIDDLE CREEK CANAL.

The daily flow of Middle Creek canal was obtained by means of the same rating flume and automatic register, that were used during the preceding year, and the results are given in the following table:

Discharge of Middle Creek. June 4 to Sept. 16, 1900.

Day.	June.	July.	August.	September.
	Cubic feet.	Cubic feet.	Cubic feet.	Cubic feet.
1	....	4,645,000	1.354.000	1.100,000
2	....	4,180,000	1,784,000	1.100,000
3	....	4,245,000	1.470,000	1,061.000
4	1,414,000	4,070.000	1,436,000	1,217,000
5	6,005,000	3.919,000	1,790,000	1.173.000
6	6,320,000	3.478 000	2 240,000	1,034.000
7	6,735,000	3 120,000	2,181,000	1,000,000
8	6,620,000	3,690.000	1,875.000	1,019,000
9	6.422,000	2.981.000	1,780,000	1.034.000
10	5,985,000	2.800.000	1,865,000	1,079,000
11	5,801,000	2 550,000	1.961.000	1,705,000
12	6,405.000	3 280,000	1,955.000	1.112.000
13	7.180,000	2,392 000	1,140 000	1.060,000
14	7,185,000	2.145 000	1.765,000	1.182,000
15	7.630.000	1,989.000	1 765,000	1.113,000
16	7,899,000	1,811,000	1,818 000	1,321,000
17	7,700.000	1.993,000	1 613,100	....
18	6,651.000	1.955.000	1,640,000	....
19	6.501,000	1.788,000	1,450 000	....
20	5,980,000	1,995,000	1.292 000	....
21	6,251,000	1.959.000	1.278,000	....
22	7,095,000	1.915.000	1.240.000	....
23	7,418,000	1.949,000	1.249.000	....
24	7,118,000	2,020,000	1.163 000	....
25	6 950.000	1.968,000	1,095.000	....
26	7.199,000	2.740,000	1,100.000	....
27	6.250,000	2 580,000	1,109.000	....
28	4.635.000	2.575,000	1,099.000	....
29	4,590,000	2.581.000	1,105,000	....
30	4,635.000	2,231,000	1,100,000	....
31	....	1,755 000	1,100,000	....
Total	170,614,000	83,300,000	46,812.100	17.700,000
Total for the season	....	....	....	318,426,100

From June 4 to September 16, 1900, the quantity of water diverted through the headgates of this canal was 318,426,100 cubic feet, or 7,310 acre-feet. Dividing this latter number by 3,853 acres, the area irrigated, the quotient 1.89 represents in feet the average depth of water applied.

In 1899 the average depth of water applied was 2.11 feet. There was a more abundant supply in Middle creek and the season was not so dry as that just closed. This difference between the available water supply and the rainfall of the two seasons accounts for the difference in the duty of water.

DUTY OF WATER IN YELLOWSTONE COUNTY.

This county extends from the central part of the state eastward a distance of about 90 miles, and comprises an area of 4,500 square miles. The Yellowstone river forms its southern boundary.

This part of the state has an abundant supply of water. The flow of the Yellowstone at Livingston, Montana, varies from 200,000 to 600,000 Montana statutory inches during the irriga-

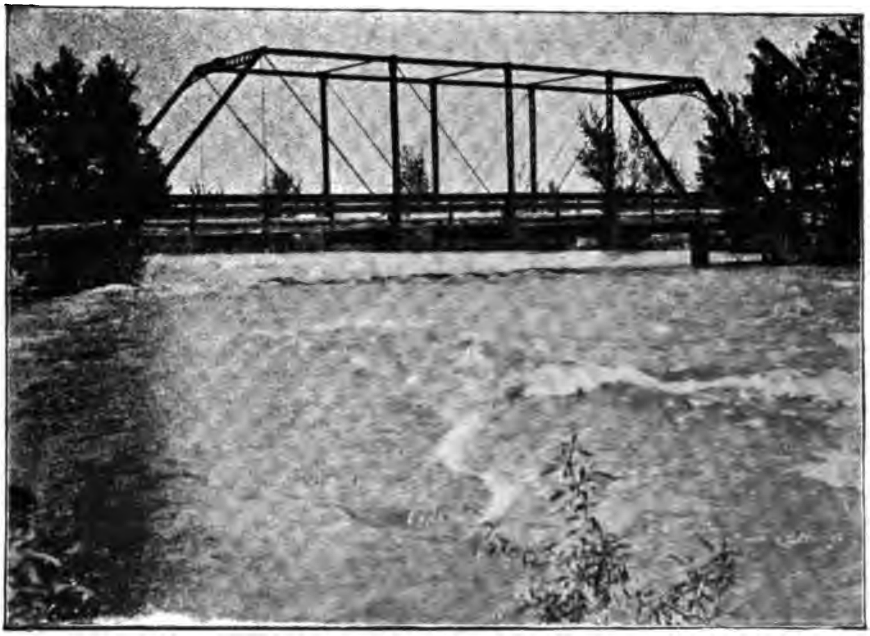


FIG. 4.—GAGING STATION ON WEST GALLATIN RIVER AT WILLIAMS' BRIDGE.

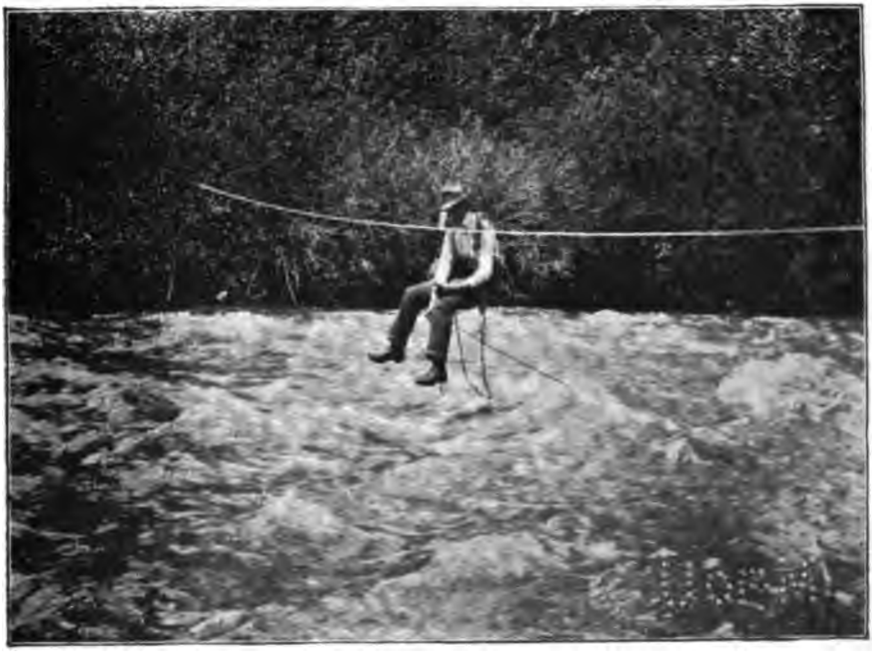


FIG. 5.- MEASURING MIDDLE CREEK IN FLOOD TIME.

M40U

tion period. In addition to the main river, there are the large tributaries of Boulder, Stillwater, and Clarke's Fork, besides about thirty small creeks that provide an irrigating supply for the counties of Sweetgrass, Carbon and Yellowstone.

Irrigation is still in the early stages of development in this county. Little was accomplished in reclaiming its large tracts of tillable land prior to 1885, but during the past ten years the growth along agricultural lines has been remarkable. The principal irrigation ditches in operation at the present time are the following:

(1.) The Yellowstone Ditch, which diverts water from the Yellowstone river at the Rapids above Park City, and extends to Valley creek.

(2.) The Big Ditch, which diverts water from the same river just below the Rapids, and extends towards the city of Billings, a distance of 39 miles.

(3.) The Italian Ditch, which heads above Park City, and extends to Laurel, a distance of 15 miles.

(4.) The Old Mill Ditch, which also heads above Park City, and terminates opposite the town of Laurel, its total length being about 15 miles.

(5.) The Canyon Creek Ditch has its source near Laurel, and waters a portion of the country between Laurel and Billings.

(6.) The Suburban Ditch heads at Canyon creek, and extends to Billings, a distance of five miles.

Investigations were begun in May, 1900, in Yellowstone county, for the purpose of determining the quantities of water used by the irrigators and the percentage of loss in conveyance. For the results of the experiments on the loss due to seepage and evaporation, the reader is referred to the information given under that heading.

In order to ascertain the quantities of water applied to the various crops in this section of the state, measuring stations were established at three different points of the Big Ditch, and a daily record kept of the flow at each from May 25 to September 27. The first of these stations was placed at Tilden's ranch, about five miles below the headgates on Yellowstone river; the second at Park City, and the third at the Hesper farm, located 11 and 27 miles respectively below the headgates.

In the accompanying table is given the daily flow in both cubic feet per second and Montana miner's inches, as well as the volumes in cubic feet at the Tilden rating station, from May 25 to September 27, inclusive.

Daily discharge of Big Ditch at Tilden's ranch, five miles below head-gates.

Date.	Gage ht. in feet.	Discharge.		Total daily discharge in cubic feet.
		Second-feet.	Montana miner's inches.	
1900.				
May 25	1.9	132.5	5300	11,448,000
” 26	1.95	137	5480	11.836,800
” 27	2.2	162.6	6504	14.048,640
” 28	2.1	152.5	6100	13,176,000
” 29	2.15	158	6320	13,651,200
” 30	2.25	168.5	6740	14,558.400
” 31	2.5	194.8	7792	16.830,720
June 1	2.5	194.8	7792	16 830,720
” 2	2.5	194.8	7792	16 830,720
” 3	2.7	215.5	8620	18,619,200
” 4	2.9	237	9480	20,476,800
” 5	3.1	258	10320	22,291,200
” 6	3.1	258	10320	22.291,200
” 7	3.1	258	10320	22,291,200
” 8	3.1	258	10320	22,291,200
” 9	3.1	258	10320	22,291,200
” 10	3.1	258	10320	22 291,200
” 11	3.1	258	10320	22,291,200
” 12	3.1	258	10320	22,291,200
” 13	3.1	258	10320	22.291,200
” 14	3.1	258	10320	22,291,200
” 15	3.1	258	10320	22,291.200
” 16	3.1	258	10320	22,291,200
” 17	3.1	258	10320	22 291,200
” 18	3.1	258	10320	22,291,200
” 19	3.1	258	10320	22,291,200
” 20	3.1	258	10320	22,291,200
” 21	3.1	258	10320	22,291,200
” 22	2.9	237	9480	20,476,800
” 23	2.9	237	9480	20,476,800
” 24	2.9	237	9480	20,476,800
” 25	2.9	237	9480	20,476,800
” 26	2.95	242.5	9700	20,952,000
” 27	2.95	242.5	9700	20,952,000
” 28	3.0	248	9920	21,427,200
” 29	2.9	237	9480	20,476,800
” 30	2.9	237	9480	20,476,800
July 1	2.9	237	9480	20,476,800
” 2	2.9	237	9480	20,476,800
” 3	2.9	237	9480	20,476,800
” 4	2.9	237	9480	20,476,800
” 5	2.9	237	9480	20,476.800
” 6	2.9	237	9480	20,476,800
” 7	2.9	237	9480	20,476.800
” 8	2.9	237	9480	20,476,800
” 9	2.9	237	9480	20,476,800
” 10	2.9	237	9480	20,476,800
” 11	2.9	237	9480	20,476,800
” 12	2.8	226.5	9060	19,569,600
” 13	2.9	237	9480	20,476,800
” 14	2.8	226.5	9060	19,569,600
” 15	2.8	226.5	9060	19,569,600
” 16	2.8	226.5	9060	19,569,600
” 17	2.6	205	8200	17,712,000
” 18	2.6	205	8200	17,712,000
” 19	2.5	195	7800	16,848,000
” 20	2.6	205	8200	17,712,000
” 21	2.5	195	7800	16,848,000
” 22	2.5	195	7800	16,848,000
” 23	2.5	195	7800	16,848,000
” 24	2.5	195	7800	16,848,000
” 25	2.5	195	7800	16,848,000
” 26	2.5	195	7800	16,848,000

Date	Gage ht. in feet.	Discharge.		Total daily discharge in cubic feet.
		Second-feet.	Montana miner's inches.	
July 27	2.4	184.5	7380	15,940,800
" 28	2.6	205	8200	17,712,000
" 29	2.6	205	8200	17,712,000
" 30	2.5	195	7800	16,848,000
" 31	2.5	195	7800	16,848,000
Aug. 1	.45	189.5	7580	16,372,800
" 2	2.4	184.5	7380	15,940,800
" 3	2.4	184.5	7380	15 940,800
" 4	2.4	184.5	7380	15,940,800
" 5	2.4	184.5	7380	15,940,800
" 6	1.7	113.5	4540	9,806,400
" 7	2.3	174	6960	15.033,600
" 8	2.3	174	6960	15,033,600
" 9	2.1	147 5	5900	12,744,000
" 10	2.1	147.5	5900	12,744,000
" 11	2.3	174	6960	15,033,600
" 12	2.2	162.6	6504	14,048 640
" 13	2.1	147.5	5900	12,744,000
" 14	2.1	147.5	5900	12,744,000
" 15	2.1	147.5	5900	12.744,000
" 16	2.1	147.5	5900	12,744,000
" 17	2.2	162.6	6504	14.048,640
" 18	2.2	162 6	6504	14,048,640
" 19	2.3	174	6960	15,033,600
" 20	2.3	174	6960	15,033,600
" 21	2.2	162.6	6504	14,048,640
" 22	2.2	162.6	6504	14,048,640
" 23	2.2	162.6	6504	14,048.640
" 24	2.2	162.6	6504	14,048,640
" 25	2.2	162.6	6504	14,048,640
" 26	2.2	162.6	6504	14,048,640
" 27	2.2	162.6	6504	14,048,640
" 28	2.2	162.6	6504	14,048,640
" 29	2.2	162.6	6504	14,048,640
" 30	2.1	147.5	5900	12,744,000
" 31	2.0	142.5	5700	12,312,000
Sept. 1	2.0	142.5	5700	12.312,000
" 2	2.0	142.5	5700	12,312,000
" 3	2.0	142.5	5700	12.312,000
" 4	2.0	142.5	5700	12,312,000
" 5	2.0	142.5	5700	12,312.000
" 6	1.9	132.5	5300	11,448,000
" 7	1.9	132.5	5300	11.448,000
" 8	1.9	132.5	5300	11.448,000
" 9	1.9	132.5	5300	11,448,000
" 10	2.1?	147.5	5900	12,744,000
" 11	2 ?	142.5	5700	12,312,000
" 12	2 !	142.5	5700	12,312,000
" 13	2 ?	142.5	5700	12,812,000
" 14	1.9	132.5	5200	11,448,000
" 15	1.9	132.5	5300	11,448,000
" 16	1.9	132.5	5300	11,448,000
" 17	1.8	122 5	4900	10.584,000
" 18	1.8	122.5	4900	10,584,000
" 19	1.8	122.5	4900	10,584,000
" 20	1.8	122.5	4900	10,584.000
" 21	1.7	113.5	4540	9,806,000
" 22	1.7	113.5	4540	9,806.000
" 23	1.6	101.5	4180	9,028,800
" 24	1.6	104.5	4180	9,028,800
" 25	1.6	104.5	4180	9,028,800
" 26	1.6	104.5	4180	9.028,800
" 27	1.6	101.5	4180	9 028,000

The quantities passing this station for each month are as follows:

May 25-31	95,549,760	cubic feet.
June	637,899,840	" "
July	580,132,800	" "
August	435,214,080	" "
September 1-27	298,478,880	" "
Total	2,047,275,360	" "

These results show that over 2,000,000,000 cubic feet of water passed this station during the irrigating season. As regards the area over which this large volume of water was applied, the funds available for these investigations would not permit of any actual survey, but the writer received from Mr. I. D. O'Donnell, the president and general manager of the Big Ditch company, an estimate of the areas irrigated during the past season in the various crops, the average yields, and the probable values. The following is Mr. O'Donnell's estimate:

Crops.	No. of Acres.	No. of Tons.	Value.
Alfalfa	10,000	50,000	$ 250,000
Timothy and Blue Joint	4,000	6,000	60,000
Oats	4,000	200,000	67,000
Wheat	1,500	37,500	37,500
Sundries	1,500	....	75,000
Pasture	4,000	....	3,000
Alkali	1,000	....	....
Total	25,000	....	$ 492,500

Assuming the area to be 25,000 acres, and the volume of water conveyed 2,047,275,360 cubic feet, the duty of water under this canal, irrespective of loss in conveyance, would be equivalent to that amount which would cover each acre watered to a depth of 1.88 feet, or less than one-third of a miner's inch per acre for the season. The table of discharges shows, however, that 10,320 miner's inches were applied for more than two weeks in June, and this maximum flow would be equivalent to a trifle more than two-fifths of a miner's inch per acre during the busy season.

These figures represent what may be termed the gross duty of water, and the net duty would be found after deducting all the losses due to seepage and evaporation in the canal. The loss in 22 miles of this canal last July, as stated under the head of "Loss from Seepage and Evaporation," was a trifle more than 25 per cent. of the total flow, and the quantity of water entering the farmer's headgates would only be three-fourths of the total available supply at Tilden's rating station. It will be readily seen that this reduction would increase the duty proportionately.

In addition to the general test which was made on the largest canal in Yellowstone county, and one of the largest in the state, the quantity of water used on a large field of alfalfa was also ascertained. The alfalfa field, composed of a clay loam, formed part of the Hesper farm, the property of Mr. I. D. O'Donnell. A trapezoidal weir, built under the supervision of the writer at the expense of the owner of the farm, was inserted at the highest point of the field, and a record kept of the flow over the weir during the period of ten days required to irrigate this crop. The field produced three crops of alfalfa, which averaged for the season 5.17 tons per acre, and on September 24 the fourth crop was eight inches high.

Duty of water on alfalfa in Yellowstone County.

	First Irrigation.
Date of Irrigation	July 17-27
Duration of Irrigation ....hours..	240
Area irrigated ....acres..	53.4
Water used ....acre-feet..	69.5
Average depth of water applied	1.30
*Rainfall, May 1, to Sept. 15	.44
Total depth of water received during growth ....feet..	1.74
Number of irrigators	....
Average head of water used ....cu. ft. per sec..	3.52
Average distance between laterals	....

*Bozeman record.

IRRIGATION INVESTIGATIONS IN THE BITTER ROOT VALLEY.

The Bitter Root valley, from an agricultural point of view, is one of the most important in Montana, and one of the most beautiful in the Rocky Mountain region. Irrigation investigations were begun in May, 1900, and continued throughout the season. The cost of traveling between the Yellowstone, Gallatin and Bitter Root valleys took a part of our small appropriation, and the work of the past season in western Montana would have been limited in extent had it not been for the generous aid extended to the writer by the officers of the Bitter Root Stock Farm. The materials and labor necessary to construct three large trapezoidal weirs, one rating flume, and several rating stations, were obtained from this source. A rating station was established near the head of each of the large canals taken out of the Bitter Root river and Skalkaho and Gird creeks soon after the beginning of the irrigation season, and daily records kept by Mr. Kippen, in charge of irrigation, of the amount of water flowing in each. If these stations and records can be maintained for another season, it will be possible to ascertain the duty of water during two seasons of an irrigated area of about 15,000 acres.

The upper part of the valley consists of bottom lands, lower bench lands, and upper bench lands. The older ditches, such as the Surprise and Republican, water the river bottoms; the intermediate ditches, such as the Ward, and Hedge, water the lower bench; while of late years long high-line ditches, such as the Upper Gird, have been constructed to supply water to the upper benches. These water courses, located one above another, on the sloping bench of the Bitter Root river, complicate the problem of seepage water. Already some of the farms, and especially the orchard tracts, are depreciating in value, owing to an excess of seepage water from the higher benches. This injury to low-lying lands will continue to increase if radical measures are not taken either to lessen the waste or construct intercepting drains. Before attempting any improvements of this character, it is advisable to ascertain the loss from seepage in each canal.

In another part of this report will be found the results of seepage experiments on the Republican canal. As this canal skirts the river throughout the greater part of its course, the seepage water escaping therefrom soon reaches the river channel, and can therefore do little damage, although it is essential to know the quantity wasted in order to divide equably the balance. It is to be hoped that similar experiments may soon be made on the highline canals in order that the loss in each may be known, and measures taken to prevent serious damage to adjacent lands.

DUTY OF WATER.

EXPERIMENT NO 1.

The first experiment on the duty of water in the Bitter Root valley was made on a forty-acre tract of five-year-old orchard trees located on the Lower Ward ranch of the Bitter Root Stock farm.

The soil to a depth of six inches is a light vegetable loam, and beneath this top layer to a depth of four feet are to be found gravel and cobble rock.

The water was measured over a trapezoidal weir box twelve feet long, and a weir notch three feet long. The rainfall during the growing season was obtained from Mr. C. W. Dougherty, weather observer at Corvallis, a few miles distant. This rainfall, together with the water applied in four irrigations, would have covered the orchard, provided there was no waste, to a depth of a trifle more than 18 inches.

The results of this experiment are given in the following table:

Duty of water on orchard—Bitter Root Stock Farm.

	First Irrigation.	Second Irrigation.	Third Irrigation.	Fourth Irrigation.	Total.
Date of irrigation	*April 28–30	June 7–13	July 9–14	August 12–14	
Duration of irrigation ... hours	58	153.5	135.5	57	394
Area irrigated ... acres	40	40	40	40	40
Water used ... acre-feet	12.25	17.57	28.03	1.36	59.31
Average depth of water applied .. feet	.31	44	.68	.03	1.46
Rain-fall, May 1st to Aug. 14th ... feet	....	....	....	....	.13
Total depth of water received during growth ... feet	....	....	....	....	1.57
Number of irrigators					
Aver. head water used .. cu. ft. per sec.	2.56	1.39	2.61	2.9	

*Approximate.

EXPERIMENT NO. 2.

The second experiment was made on a large field of oats containing 161.7 acres, located on the Prendergast ranch of the Bitter Root Stock farm.

The field slopes at the rate of nearly 45 feet to the mile, and the soil consists of about a foot of black vegetable loam overlying an unknown depth of coarse gravel. This field was seeded April 15, and cut August 10, and the yield was 5,396 bushels of 35 pounds to the bushel.

The accompanying table shows that the total quantity of water applied was 1.30 feet of irrigating water, and 0.13 feet of rain, or 1.43 feet in all, which equals about 17 inches.

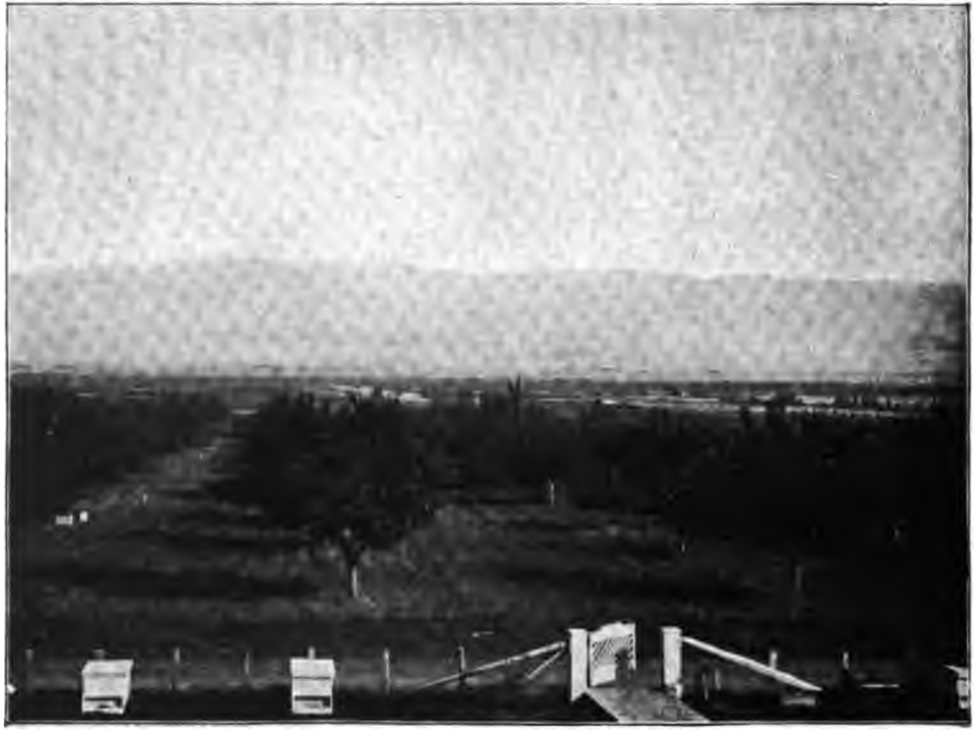


FIG. 8.—AN ORCHARD IN THE BITTER ROOT VALLEY.

Duty of water on oats—Bitter Root Stock Farm.

	First Irrigation.	Second Irrigation.	Total.
Date of irrigation	May 22–June 11	July 21-30	
Duration of irrigation ... hours..	490.5	226.5	717
Area irrigated ... acres..	161.7	161.7	161.7
Water used ... acre-feet..	125.75	81.33	206.98
Average depth of water applied ... feet..	.79	.50	1.30
Rain-fall, April 15th to August 10th ... feet..			.13
Total depth of water received during growth.feet..			1.43
Number of irrigators			
Average head of water used ... cu. ft. per sec..	3.16	4.35	
Average distance between field laterals ... feet..			175

EXPERIMENT NO. 3.

This experiment was made on a high gravelly bench traversed by numerous ravines, and is a typical example of the enormous quantities of water that may be applied to certain bench lands by the ordinary methods of irrigating as practiced in the mountain states.

On this particular field of oats, containing 102.2 acres, located on the Gilchrist ranch of the Bitter Root Stock farm, and supplied with water from the Skalkaho ditch, the farm laterals were from 150 to 200 feet apart, and the irrigators were on duty nine hours out of every twenty-four. The yield was 3,478 bushels of oats.

The data pertaining to this experiment are given in the following table:

Duty of water on oats—Bitter Root Stock Farm.

	First Irrigation.	Second Irrigation.	Total.
Date of irrigation	May 23–June 19	July 19–Aug. 8	
Duration of irrigation ... hours..	656.08	418.17	1074.25
Area irrigated ... acres..	102.2	102.2	102.2
Water used ... acre-feet..	347.46	265.87	613.33
Average depth of water applied ... feet..	3.43	2.63	6.06
Rainfall, April 15th to August 10th ... feet..			.13
Total depth of water received during growth.feet..			6.17
Number of irrigators			2
Average head of water used ... cu. ft. per sec..	6.41	7.69	
Average distance between field laterals ... feet..			175

SEEPAGE IN ITS RELATION TO THE DUTY OF WATER.

SEEPAGE DEFINED.

The term seepage has a somewhat wide meaning in the irrigated sections of the west. In its broader sense it includes the water which is derived from the absorptive materials of uncultivated hillsides and mountain slopes, as well as that which flows beneath the beds of streams. In its narrower sense, it is confined to the water which escapes, or seeps, from ditches, canals, reservoirs, and irrigated lands.

For countless ages that portion of the rainfall and melted snow which if not evaporated sooner or later flows down the natural river courses to the sea. But the western pioneer soon learned that a part of the water which thus escaped, if diverted and applied to his fields, would treble his yearly income from the farm. The knowledge of this fact has induced men to expend enormous sums of money in diverting the flow of streams from their natural beds into myriads of artificial channels, which form a network of water courses over areas that were once dry and barren. In this way the slow and gradual processes of nature have been interfered with. Man's necessities have forced him not only to utilize the water of the stream, but to convey it to distant places, from which return to the same stream channel may be impossible. For over half a century this diversion of water has been going on in the West, and the student of irrigation is now compelled to stop and study the effects produced. Much of this change from natural conditions is due to that part of appropriated waters which is wasted rather than to that which subserves a useful purpose.

In the orchards of Southern California seepage water is of insignificant amount and of minor importance, for the reason that little water is allowed to escape. Through the use of cemented ditches and closed pipes the water is conveyed without loss from the source to the orchard tracts. The same economy is practiced in its application to the fruit trees. By frequent cultivation evaporation is diminished, and the skillful irrigator endeavors to produce the desired results with the minimum quantity of water. In the Rocky Mountain states the conditions are quite different

Water is much more abundant. Instead of using impervious channels, such as lined canals and closed pipes, water is conveyed in open ditches over porous formations of loose earth and gravel. The mode of irrigating known as flooding is usually practiced, not because it is the most economical of water, but because it is the cheapest. In view of the fact that large volumes of water are daily diverted and applied to dry soil during the summer season in such a manner as to admit of a large percentage of waste, it is not surprising that this waste or seepage water becomes an important factor in the irrigation of a district.

SEEPAGE FROM IRRIGATION CANALS.

Whenever water is conveyed in channels excavated in ordinary soils and subsoils a large percentage of the flow is absorbed by the porous materials forming the bottom and sides of the channel. In the past writers on irrigation have frequently attributed this loss to evaporation and seepage. This may account for the false impression that prevails among irrigators as to the real cause of the loss. Many claim that it is chiefly due to excessive evaporation. This was the belief of an intelligent water-master whom the writer met last summer. This man, after thirteen years of continuous service in operating a canal, had reached the conclusion that the loss in conveyance which formed about one-third of the total flow, was due almost wholly to evaporation. While as a matter of fact, the loss due to evaporation was so small when compared with that from seepage as to be scarcely worth mentioning. On this particular canal the quantity of water evaporated during a hot day in midsummer would be equivalent to the continuous flow of one cubic foot per second for the same period, while the quantity which was lost by seepage amounted to about 75 cubic feet per second. In other words, the loss due to seepage was seventy-five times greater than that due to evaporation. It is true that a large part of the water used in irrigating is evaporated, but this takes place after the water has been spread out on the fields, and not to any great extent while it is confined in the canal.

This fact should be clearly understood by the irrigators, otherwise the defects in existing canals will not soon be remedied. So long as the owners believe that the loss of water is principally due to evaporation, over which they have practically no control, they will be content to let things alone. Whereas, if the truth is made clear to them, that evaporation from the surface of their canals is insignificant, and that from fifty to a hundred times more water escapes through the lining of the bottom and sides, they will realize that this great loss may be in a measure prevented, and that the stream which now waters only seventy-five acres may, if conveyed in a more impervious channel, supply water for one hundred acres.

PERCENTAGE OF LOSS DUE TO SEEPAGE.

WEST GALLATIN IRRIGATION CANAL.

This canal diverts water from the West Gallatin river in Gallatin county, Montana. Its intake is near the mouth of the canyon of the same name, and its general course is northwesterly. In capacity, original cost, and total length, this canal takes precedence over all others in Gallatin valley.

For the first quarter of a mile it runs parallel to the river in deep cuttings and considerably below the bed of the river to obviate the necessity of constructing and maintaining a diversion dam. This portion was excavated to a width of 24 feet on a grade of 10.56 feet per mile. At its lower end are placed secondary gates, with wastegates to allow the surplus water to flow back into the river. Owing to the rapid descent of the river, the location of the canal soon reaches the left bank of the narrow river valley, and from thence extends along the steep hillside in a continuous series of sharp curves which the numerous ridges and deep ravines necessitate. The formation varies from a loose vegetable loam on top to sand, gravel and boulders beneath, overlying a soft sand rock, which is locally termed mud rock. The softer portions of this sand rock are readily disintegrated by seepage water from the canal, and the harder portions frequently form the bed of the graded canal, so that it is difficult to prevent the water from percolating between the subsoil and the rock formation. These unfavorable conditions have caused a considerable number of bad breaks in the upper ten miles, and increased the loss due to seepage.

With the exception of the first quarter of a mile, the bottom width at the time of construction was intended to be 14 feet throughout the length of the main canal on a grade of a trifle over three feet per mile, and with earth slopes in excavation of one vertical to one horizontal. The action of the water, however, in ten years has produced many changes. Owing to the deposits of material at the inner edge, and the placing of rip-rap on the outer slope, the width is now reduced in many places to less than 12 feet.

In the ninth mile from the intake a tunnel 241 feet long was excavated to avoid a long detour around a ridge. This tunnel is twelve feet wide and about six feet high on a steep grade.

Twenty-three miles from the source the canal divides into what is known as the Green lateral and the Hammond canal. The Hammond canal extends from the division gates, a distance of nine miles, to what is known as the "Drop," where the grade descends rapidly through a vertical elevation of 300 feet to the head of Camp creek. From the foot of this drop the canal is again diverted on grade and is called Camp creek lateral to its present terminus near the 39th mile post from the headgates on the West Gallatin river.

The accompanying table shows that the loss from seepage and evaporation throughout the entire length of the main canal, a distance of 38¾ miles, was 39.8 cubic feet per second, or 34.7 per cent. of the quantity diverted from the river.

Loss from seepage and evaporation on the West Gallatin canal.

Date of experiment.	Duration of experiment.	Volume received at upper end of canal section.	Volume discharged through laterals.	Volume discharged at lower end of canal section.	Volume lost in section of canal.	Length of section.	Length of wetted perimeter.	Width of water surface.	Per cent of total supply lost.
	Hrs.	Sec.-ft.	Sec.-ft.	Sec.-ft.	Sec.-ft.	Miles.	Feet.	Feet.	
July 18	....	114.45	....	107.68	6.77	3	21.97	16.72	5.92
July 18	....	107.68	....	98.71	8.97	2	19.1	12.55	7.83
July 19	(1)	98.71	....	99.56	* .85	4	20	13.70	* .74
July 19	....	99.56	46.83	37.85	14.88	14	17.15	12.45	13
July 20	....	37.85	6.71	27.98	3.16	9	12.47	9.77	2.68
July 20	(2)	28.11	11.96	11.47	4.68	2	13.42	11.9	4.08
July 20	....	11.47	....	11	.47	4¾	14.2	13.5	0.41
Total loss	....	....	....	....	39.78	....	....	....	34.66

*Gain.

(1). Measurement at head of this section taken on the evening of July 18 and at the foot the next morning.

(2). Received 0.125 sec.-ft from Camp Creek.

FARMERS' CANAL.

This canal diverts water from the West Gallatin river near the town of Salesville, in Gallatin county, and extends in a northwesterly direction for a distance of 12½ miles, terminating near the western boundary of the city of Bozeman. It was incorporated September 26, 1890, under the name of the Excelsior canal, with a capital stock of $50,000. The stockholders were all farmers who expected to use their water shares on their respective farms. The original appropriation was made for 5,000 Montana statutory inches, but in the fall of 1890, when about half of the canal was completed, the company learned that its capacity was far in excess of the appropriation. In order to utilize the actual volume conveyed and to conform to legal requirements, the same parties organized a second company called the Farmers' Canal company, which was incorporated December 23, 1892. This latter corporation purchased the water right, right-of-way, improvements, and other interests of the former company, and increased their appropriation to more than double that first claimed.

The canal from the main headgates on the West Gallatin river has a fall of one-half inch to the rod to Bear Creek slough, where a second set of headgates is inserted. From the lower headgates the route follows an old mill ditch on a grade of three-eighths of an inch to the rod, and from the old mill site to the end the bottom width is 22 feet on a grade of one-twelfth of an inch to the rod. From the upper headgates to the old mill site, a distance of 1¾ miles, the formation beneath the shallow soil is composed of gravel, cobble rock and boulders. The measurements made to determine the loss from seepage did not include the upper portion of the canal where this porous formation exists, but extended from a point 1.75 miles from the head to the end of the main canal, a distance of 10.75 miles. This portion of the canal traverses a fertile portion of the Gallatin valley, where the soil for the most part is a clayey loam and reasonably deep. The loss as given in the following table is therefore comparatively small.

On July 30, 1900, the quantity flowing past the bridge at Story's old mill was 133.1 cubic feet per second, and the loss in 10.75 miles was 23.6 cubic feet per second, or 17.7 per cent. of the total flow at the place named.

Loss from seepage and evaporation on the Farmers' canal.

Date of experiment.	Duration of experiment.	Volume received at upper end of canal section.	Volume discharged through laterals.	Volume discharged at lower end of canal section.	Volume lost in section of canal.	Length of section.	Length of wetted perimeter.	Width of water surface.	Per cent. of total supply lost.
	Hrs.	Sec.-ft.	Sec.-ft.	Sec.-ft.	Sec.-ft.	Miles.	Feet.	Feet.	
July 30	....	133.10	8.44	108.61	16.05	2¼	20.4	16.7	12.05
July 30	....	108.61	....	104.49	4.12	4¼	21.7	16.5	3.09
July 31	*(1)	105.04	67.44	34.18	3.42	4¼	17.17	13.5	2.57
Total loss	....	....	....	....	23.59	....	....	....	17.71

*(1) Received .55 sec. ft. from another source.

MIDDLE CREEK CANAL,

On July 10, 1899, an experiment was made on the main branch of this canal from the head down to where it branches into the North and East Forks. The results of this experiment showed that of a total of 98.9 cubic feet per second received through the headgates 21.5 cubic feet were lost in transmission.

The experiment in 1900 included the main canal as well as the branches. Of a total quantity of 65 cubic feet per second admitted on July 27, 19.4 cubic feet were lost in the main canal between the headgates and the Forks. In the North Fork there was a flow at the head of 9 cubic feet per second on July 28, and the aggregate of all the ditches diverting water from the branch was 11.76, showing a gain of 2.77 cubic feet per second. This is due to the fact that the seepage in this portion is more than counterbalanced by the waste water which flows into it from the adjacent irrigated fields. In the East Fork there was a slight loss, showing that the flow of seepage and waste water into the canal was less than that which escaped through the sides and bottom of its channel. The results of this experiment are given in the following table.

Loss from seepage and evaporation on the Middle Creek canal.

Date of experiment.	Duration of experiment.	Volume received at upper end of canal section.	Volume discharged through laterals.	Volume discharged at lower end of canal section.	Volume lost in section of canal.	Length of section.	Length of wetted perimeter.	Width of water surface.	Per cent. of total supply lost.
	Hrs.	Sec.-ft.	Sec.-ft.	Sec.-ft.	Sec.-ft.	Miles.	Feet.	Feet.	
June 27	....	63.04	31.19	19.61	*12.24	4	10.1	8.5	19.4
June 28	....	8.99	In North Fork. 11.76		† 2.77	2½	5.5	4.95	4.3
June 28	.. ..	10.62	In East Fork. 10.20		* .43	2	6.3	4.85	0.67

*Loss.
†Gain.

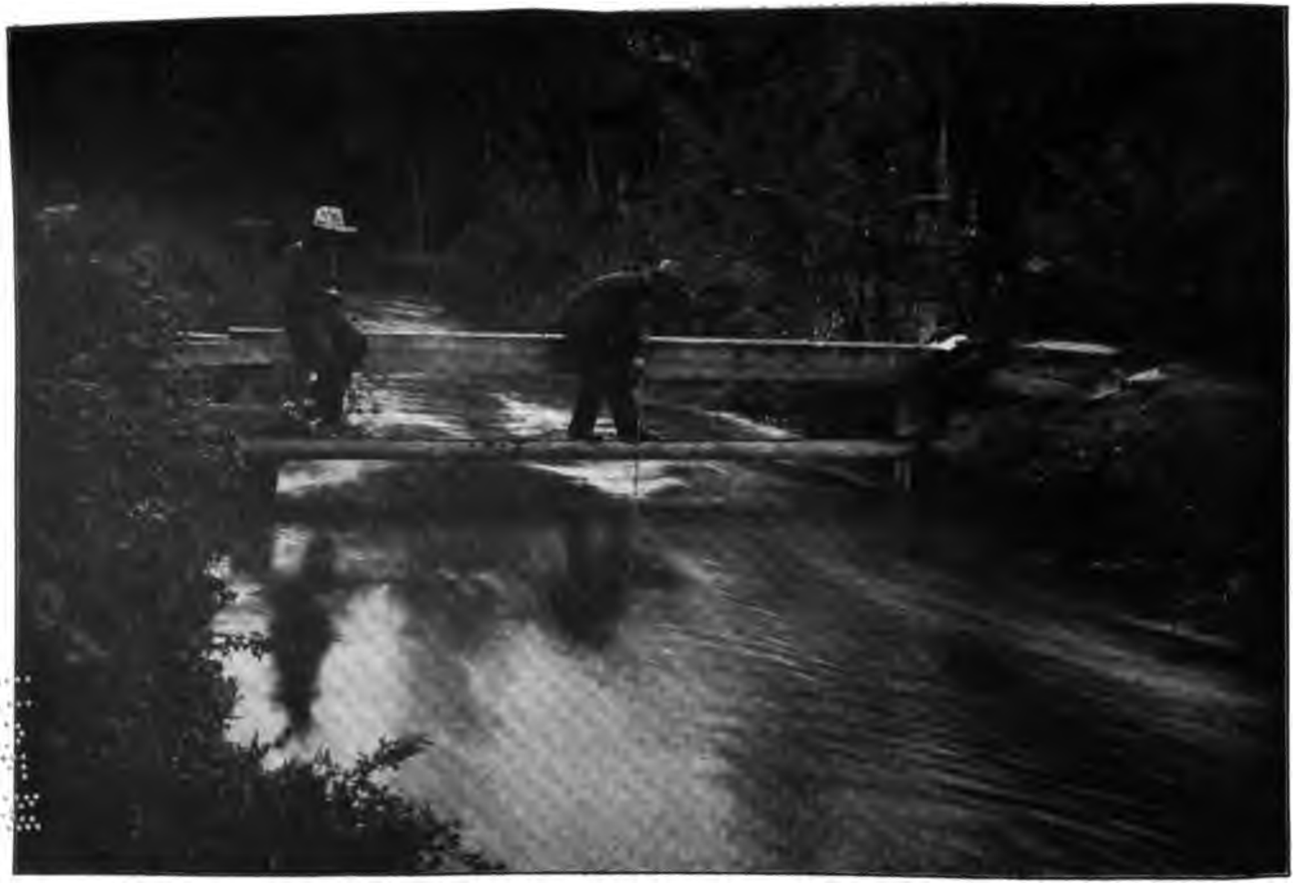


FIG. 9.—GAGING STATION OF THE REPUBLICAN CANAL, BITTER ROOT VALLEY.

LOSS DUE TO SEEPAGE IN YELLOWSTONE COUNTY.

THE BIG DITCH.

This canal was begun in 1882 by the Minnesota and Montana Land and Improvement company, and completed several years later at a total cost of $110,000, of which sum $40,000 were expended on fluming. Under the able supervision of Mr. I. D. O'Donnell the flumes across ravines have in nearly every case been replaced by earthen embankments, so that the cost of the fluming now in place would not exceed $3,000. This wise change in construction will annually save a large sum of money in repairs and maintenance. The canal as originally built was intended to be 30 feet on the bottom over the upper portion, with side slopes of 1 to 1, a water depth of 3 feet, and a grade of 2.5 feet per mile. The action of the water and atmosphere in fifteen years has made many changes.

The experiment to determine the loss from seepage was made on that portion of the canal lying between Tilden's ranch and the Hesper farm, with an intermediate measurement at Park City. The length of the upper section was 6 miles, that of the lower 16 miles. The character of the soil from the headgates to Tilden's ranch, a distance of 5 miles, is porous, consisting chiefly of sand and gravel; between Tilden's ranch and Park City it is sandy loam. Below Park City for about 5 miles it is a heavy clay soil, and beyond it is again a light sandy loam to the terminus of the canal.

The results as summarized in the following table show that on August 9, 1900, 254.47 cubic feet per second, or 10,179 Montana miners' inches, passed the upper gauging station, and of this amount 16,83 cubic feet were lost in the first 6 miles, and 48.22 cubic feet per second in the subsequent 16 miles. These make a total loss of 65.05 cubic feet per second in 22 miles, or 25.55 per cent. of the total flow.

Loss from seepage and evaporation on the Big Ditch, Yellowstone County.

Date of experiment.	Duration of experiment.	Volume received at upper end of canal section	Volume discharged through laterals.	Volume discharged at lower end of canal section.	Volume lost in section of canal.	Length of section.	Length of wetted perimeter.	Width of water surface.	Per cent of total supply lost.
Aug.	Hrs.	Sec -ft.	Sec.-ft.	Sec.-ft.	Sec.-ft.	Miles.	Feet.	Feet.	
9 and 10	48	254.47	24.76	212.88	16.83	6	31.25	29	6.61
10 and 13	60	212.88	72.18	92.48	48.22	16	29.5	26.2	18.94
Total loss	....	....	....	....	65.05	....	....	....	25.55

First section Tilden's ranch to Park City.
Second section Park City to Hesper Farm.

LOSS DUE TO SEEPAGE IN THE BITTER ROOT VALLEY.

THE REPUBLICAN CANAL, RAVALLI COUNTY.

In the spring of 1883 an agreement was entered into between C. T. Jones, A. Freeman, I. N. Davis, Frank Burgon, N. J. Tillman, B. F. Strange, James A. Chaffin, W. H. Patrick and William Hawley, of the Bitter Root valley, to construct a ditch from Skalkaho creek to Willow creek, for the purpose of furnishing water for irrigation. This association was called the Republican Ditch company. According to the terms of the agreement each shareholder had an equal interest in the ditch provided he performed an equal amount of labor in constructing and maintaining it. It was also provided that no shareholder would rent or give away his share of the water to anyone not interested in the ditch. The officers of the association were a president, secretary and foreman.

Three years later, in April, 1886, it was decided to incorporate the Republican Ditch company with a capital stock of $4,000, divided into 80 shares of $50 each.

At a meeting of the stockholders held in June, 1889, it was decided to extend the ditch from its point of diversion in Skalkaho creek to the Bitter Root river, near the mouth of Sleeping Child creek, a distance of 4⅜ miles. At the same meeting the capital stock was increased from $4,000 to $10,700, divided into 214 shares at a par value of $50 a share. New by-laws were adopted in 1896, but in other respects there have been few important changes. Of late years the Bitter Root Stock farm has made large investments in this old canal, and now has the controlling interest.

During the past year extensive and costly improvements have been made at the point of diversion. A crib dam has been constructed across the Bitter Root river for the purpose of diverting water into the Republican ditch, and the new headgates, wasteways, secondary gates, and river cribbing are substantial structures.

Prior to last spring no accurate data had been obtained in regard to the volume of water carried in this canal and the percentage of loss due to seepage; nor had any accurate means been used to divide the flow pro rata among the stockholders.

One of the objects that the writer had in view in making experiments on this canal during the past season was to introduce into this part of the state improved methods of distributing water. So long as the loss due to seepage and evaporation in twelve miles of main canal was unknown, any attempt to apportion the water equably among the stockholders would be mere guesswork. Knowing the net flow available after all losses in conveyance are deducted, it only becomes necessary to devise suitable measuring boxes which would give to each lateral its proportionate share.

The results of the experiment to determine the loss from seepage made in July, 1900, are given in the following table. The loss in the first section, from the head to the town of Grantsdale, 3 3-5 miles, is 34.33 cubic feet per second; that in the next section, from Grantsdale to the lower end of the Corvallis ranch, 6 4-5 miles, is only 3.85 cubic feet, while the loss in the remaining section to the end of the main canal at the Cowan headgate, is only 0.66 cubic feet per second. These figures show that the greater part of the loss is in the upper third of the canal through the gravelly formation extending from the headgates to the north line of the town of Grantsdale.

Loss from seepage and evaporation on the Republican canal.

Date of experiment.	Duration of experiment.	Volume received at upper end of canal section.	Volume discharged through laterals.	Volume discharged at lower end of canal section.	Volume lost in section of canal.	Length of section.	Length of wetted perimeter.	Width of water surface.	Per cent of total supply lost.
	Hrs.	Sec.-ft.	Sec.-ft.	Sec.-ft	Sec.-ft.	Miles.	Feet.	Feet.	
July 21	24	120.49	9.81	76.84	34.33	3 3-5	17.87	12.75	28.57
July 23	24	76.84	64.75	11.74	3.85	6 4-5	12.37	9.75	3.20
July 24	12	11.74	11.08	0 0	.66	1 4-5	9	8	0.55
Total loss	....	....	....	....	38.84	....	....	....	31.32

CONDITIONS AFFECTING SEEPAGE FROM CANALS.

Until recent years the question of loss from irrigation canals received little attention. The owners sought to excavate a channel of sufficient cross-section and fall to carry the desired quantity of water, but when this was accomplished, they gave little heed to the large volume which was lost in flowing through the canal. If even a small fraction of this loss had escaped over the top of a low embankment where the ditch rider could have observed it, the defect would have been at once remedied. But because the escaping water percolated through the porous bottom of the channel unobserved and without any visible effects on the surface near the right-of-way of the canal, it was permitted to flow on undisturbed. This problem, like many more connected with irrigation, is too complicated for the ordinary irrigator or canal owner to solve. It belongs by right to the scientific bureaus of the nation and the experiment stations of the west.

(1.) CHARACTER OF THE CHANNEL.—The nature of the soil through which it is proposed to build a canal greatly affects the subsequent loss by seepage. If it be composed for the most part of clay there will be but little loss from this cause. If, on the other hand, the material be either sand or gravel, the loss may be very great. In the building of canals, the source of supply, the route and the carrying capacity are carefully considered, but if the knowledge gained from other canals excavated in like material goes to show that 50 per cent. is likely to be lost in seepage, this one feature may become of prime importance. The great need at the present time is for more accurate data in relation to the seepage from canals now in operation; so that when a new enterprise is planned and the materials along the route of the proposed canal examined, it will be possible to predict within certain limits what the loss from seepage will be. If, for example, a conclusion based on accurate data were reached that the proposed canal would lose by seepage 30 per cent. of its entire flow, either the route should be changed or the style of construction modified so as to render the channel more impervious. In the past men have built canals along sandy and gravelly hillsides, knowing that the loss would be excessive at first, but hoping that the sediment borne by the water would in time fill up the interstices between the particles of the coarse material. There is no question but that this change is gradually brought about, provided the velocity of the water is such as to admit of the deposition of sediment.

Thirty-two years ago a canal known as the Utah and Salt Lake Canal was built from a place on the Jordan river known as the Jordan Narrows, and extended for a distance of about 28 miles in a northerly direction towards Great Salt Lake. The bottom width was 30 feet near the head and over the greater part of its length; the fall was 18 inches to the mile. Soon after the canal was completed and in operation, Mr. McAlister found the loss to be about 50 per cent. of the flow through the headgates. Twenty-five years later the author, by making about sixty measurements, found the loss to be 22 per cent. This canal may be taken as a type to represent a large number. The figures given above go to show that with a slight grade the open spaces through which the water percolates will in time become filled with sediment. He who waits on nature's remedy, however, may wait too long. Water is becoming too valuable to be wasted in so large quantities. In the case above referred to the loss at the end of 25 years was 40 second-feet, or 1,600 Montana inches.

(2.) VELOCITY OF THE WATER.—The rate at which water moves in a canal has much to do with the porosity of the channel and the consequent loss by seepage. When the speed is too great, the sediment and finer particles of soil are carried down by the current, leaving a bed of well washed gravel and cobble rock. Many irrigators are of the opinion that if they can convey water over loose, gravelly formations at a high rate of speed, the loss by seepage will be much reduced. There would seem to be little truth in this theory. It is a well known fact that when a channel becomes eroded by the action of water the loss by percolation is greatly increased. It is also true, as will be noticed hereafter, that the greater the depth of water the greater will be the percolation, and in a channel of low velocity, the cross-section of which the depth is an important factor, will have to be much increased over that carrying an equal amount of water at a high rate of speed. About all that can be stated in favor of this theory is that a body of water flowing at a high velocity requires a much smaller channel than a similar body flowing at a low velocity, and that, other things being equal, the loss is proportional in a way to the size of the channel. On the other hand, the results of measurements show that the loss by percolation around the perimeter of a canal on a steep grade, and eroded by the action of water, is much greater than it would be if the grade were reduced, the velocity low, the bed lined with sediment, and the cross-section increased.

Much of the loss due to seepage from the canals in this state is traceable to the injurious effects of steep grades, high velocities, and channel beds that are scoured clean of all sediment and clay. Laterals have been built on the natural slopes of the country irrespective of the fall. In many instances the fall is from 50 to 100 feet per mile, and the effect of the high velocity thus produced is to wash away the bed until a porous, rocky formation is reached. In places where the soil is deep the effect of the current is to undermine the banks, which cave in and are washed down stream, thus forming wide and deep chasms through cultivated farms that detract much from their appearance and value.

One of the most difficult tasks in canal construction is to adjust the grade in such a way that the water will move neither too rapidly nor too slowly. Some of the injurious effects of too high velocities have already been noted; those resulting from a sluggish current are the lessened carrying capacity, the gradual formation of sediment until the channel is much reduced in area,

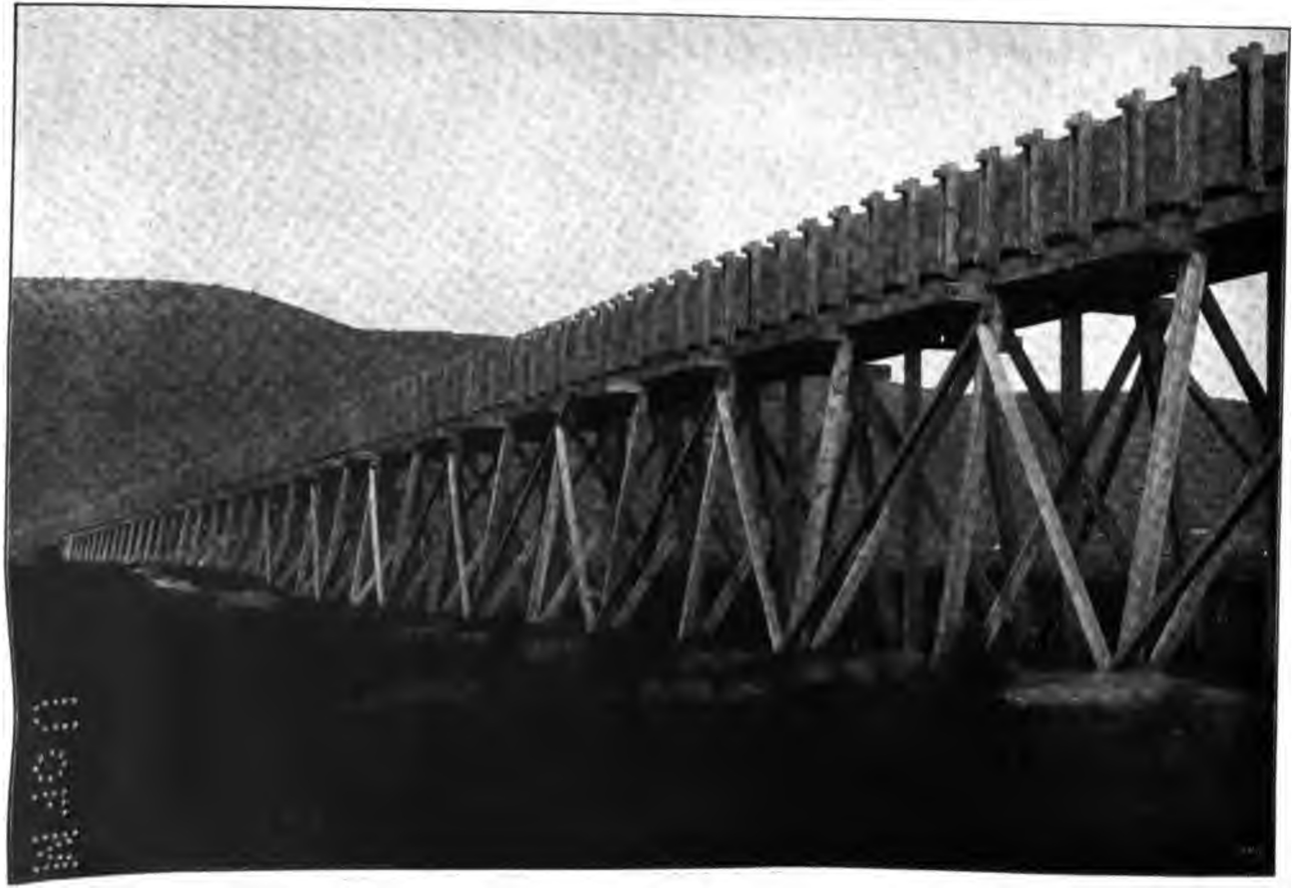


FIG. 10.—FLUME ON TRESTLES ACROSS SLEEPING CHILD HOLLOW, BITTER ROOT VALLEY.

U of M

M tcU

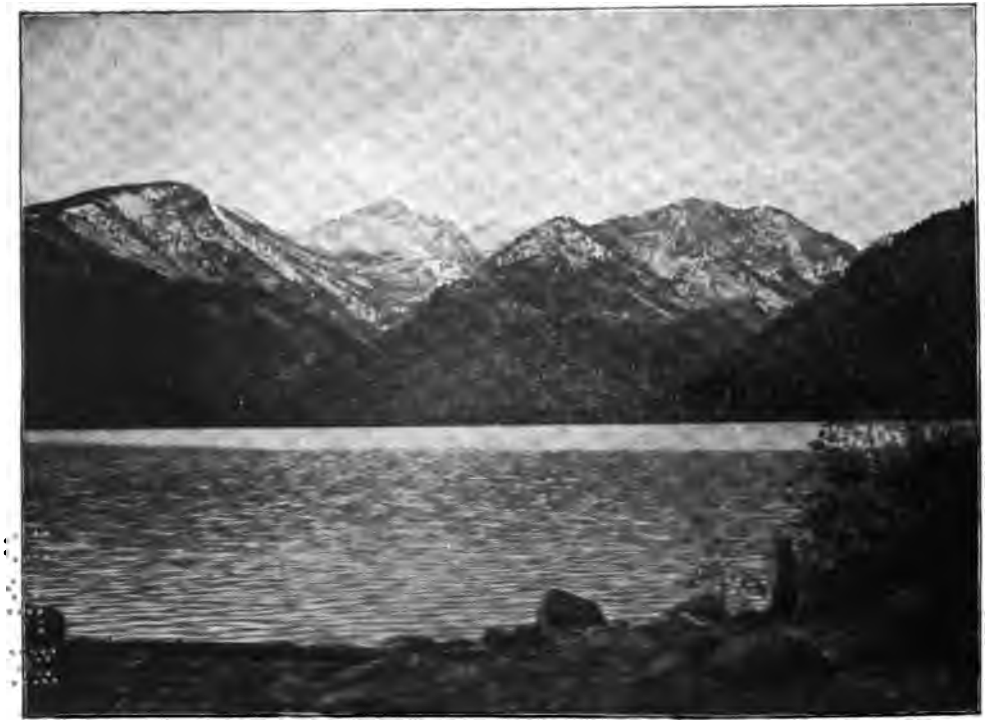


FIG. 11.—LAKE COMO, A NATURAL STORAGE RESERVOIR OF THE BITTER ROOT VALLEY.

and the growth of aquatic plants. Experience has shown that in ordinary soils a mean velocity of from 2½ to 2¾ feet per second may be used without incurring any risk of filling the canal with silt, or, on the other hand, of having the bottom scoured by too rapid a current.

(3.) MANNER OF BUILDING.—There is usually a right and a wrong way of doing things, and canal building is no exception to this rule. If built in the wrong way the owner pays yearly tribute to the defects in the original construction in the form of water lost by seepage. A common defect is to form the embankments on top of the original surface without first plowing up the sod or removing the weeds and sagebrush. The result is a leakage along the original surface whenever the water in the canal rises above the excavated portion. The surface beneath the embankments should first be plowed deep, all vegetable matter removed, and a water-tight joint, as it were, made between the made earth and the natural soil.

In the early days of irrigation in Colorado, when the author first went to that state, they built canals in much the same way as they dug their cellars. The sole aim seemed to be the removal of the earth from the canal site, to be heaped on the edges without any regard to either appearance or utility. Experience has since taught the irrigators of the West that every yard excavated should be made to serve the double purpose of making a channel and forming an embankment. To accomplish this end, the top of the embankments should be as regular and as true to grade as the bed of the canal. The sole purpose of a canal is to convey water from one place to another, but if one-third seeps through the bottom and sides along the route, the usefulness of such a canal may be called in question. It is not enough that we merely provide a channel for the water to flow through, we should also ascertain if it will hold water. If not, the proper time to remedy so serious a defect is when the canal is being built. It costs but a trifle more to excavate the bed a few inches below grade and fill the space thus made with good puddle. If this were done at the worst places along the route, the value of the water thus saved for one season would frequently pay for the extra cost involved.

(4.) VOLUME OF WATER CONVEYED.—The loss from seepage usually varies more or less directly with the volume carried. When water is fisrt turned into new ditches and canals the loss may be excessive for the first season, but in time, if the grades have been properly adjusted, a coating forms over the bottom and sides which diminishes the loss. If the water is held at the same level for a number of seasons there will be little change in the volume lost by seepage. As soon, however, as the water in the canal is raised, the pressure is not only increased, but new surfaces uncoated by silt come in contact with the water and increase the loss. This fluctuation in the quantity of seepage water makes it difficult to apportion the water equably among shareholders. Except in the case of old canals, the area of land watered by each is annually increased, and every additional acre reclaimed calls for an extra supply of water. This yearly change is, after all, perhaps not so important as the fluctuations during the irrigation season. Only a small amount may be turned in at first, but as the season advances the supply is gradually increased until a full head is reached. This full head is maintained until the crop begins to mature, when a portion is turned off, and the supply is gradually reduced until there may be only enough left in the canal to water stock. This gradual increase in the volume carried in the spring, followed by a gradual decrease in the fall, causes a corresponding fluctuation in the quantity which seeps through the bottom and sides of the canal.

In view of the conditions named above it would be difficult to determine for each definite volume carried the percentage of loss. The most that can be expected is the making of tests during periods of maximum flow. The results will enable the superintendent, or ditch rider, to allow the necessary amount for waste, and apportion the balance to the rightful owners, at a time when all the water is needed. The amount wasted in spring or fall when the canal is only partly filled is less important; for the reason that there is no scarcity of water. The supply is adequate for all demands. Experiments on seepage should therefore be made with a full head in order that the greatest loss may be known, and the total flow diminished by this loss would represent the volume available at the headgates of the farmers' laterals.

HOW TO LESSEN THE SEEPAGE LOSS FROM CANALS.

The quantity of seepage water from canals not only reduces the available supply, but frequently damages low-lying adjacent lands. In estimating the cost of making canals more impervious, it is well to consider this question of depreciation in land values. Whenever there are good reasons to believe that the water which escapes from canals is creating marshes or causing the rise of alkali in what were formerly fertile tracts, an additional expenditure may be made in order to prevent or lessen such damage.

Various devices have been used in different parts of the West to decrease the loss from earthen canals or ditches. Of these the wooden flume is the most common. Over a decade ago enormous sums of money were expended in building wooden flumes on irrigation systems. It was found, however, that these structures, particularly when they came in contact with the soil, had to be renewed in from six to ten years. So many perishable structures greatly increased the annual cost of maintenance. To lessen this heavy yearly expenditure other devices, such as wooden stave pipes kept under pressure, cement and asphalt concrete linings and well puddled earth were introduced.

Both land and water are still moderately cheap in Montana, and it would not pay to expend any large sum of money in either preventing or lessening the seepage flow. Pipes of all kinds at current prices are expensive, and the climatic conditions might render both asphalt and cement concrete linings unsuitable.

CLAY PUDDLE.—Much of the water now wasted in conveyance might be saved by the use of clay puddle. Clay and water, or clay and water mixed with sand and gravel, will make good puddle. These materials are both cheap and abundant, and can usually be found along the route of the canal. New canals over gravelly bars should be excavated about nine inches below grade, and this space filled with clay. The bed may then be harrowed to reduce the clay to fine particles. It should then be dampened either by a street sprinkler or by allowing a small amount of water to flow through the channel. By driving stock, preferably sheep, back and forth over the canal, when the clay is sufficiently moist, a good puddle will be formed.

Should the current be liable to wash away the puddled clay a layer of gravel should be placed over it and well rammed down either by the feet of animals or by the use of tamping bars. The sides of the ditch or canal can best be lined by making an extra quantity of puddle in the bed and placing a part on each side. For this purpose the clay should be mixed with gravel to make it more rigid.

Last spring Mr. M. D. Kippen, of Hamilton, Montana, introduced a novel method of preventing seepage. The canal was new, and when water was first turned in there was not only an excessive amount of seepage, but a break occurred at a gravelly point on the steep sidehill. To make this portion of the canal safe the bed and slopes were excavated to a depth of from four to six inches below grade. Gunny sacks were then cut open, sewed together, laid with a slight lap over the bottom, and held down by cleats. The best material available, which in the case under consideration consisted of vegetable loam, was then placed over the sacks to a depth of from four to six inches. About two months later the writer examined the part of the canal lined in the manner described and found it to be water-tight when under a medium head of water.

ACKNOWLEDGEMENTS.

In conclusion the author takes pleasure in acknowledging the able assistance rendered by Prof. J. H. Gill, M. E., in calculating the results of stream measurements and in preparing the necessary drawings.

Messrs. H. B. Waters and W. B. Freeman, students in engineering of the Montana Agricultural College, did careful work in collecting field data during the summer season.

Acknowledgements are also due to the valuable aid rendered gratis by Mr. I. D. O'Donnell, of Billings; Mr. George Watt, of Park City; Mr. E. C. Kinney, M. Am. Soc. C. E., of Bozeman, and Messrs. B. McGinty, P. A. Shannon, and M. D. Kippen, of Hamilton, Mont.

Electrotypes of a number of the cuts contained in this bulletin were obtained from Mr. F. H. Newell of the United States Geological Survey.

The author had also access at all times to the valuable records kept by Prof. R. S. Shaw, and the information herein given in regard to the products of the Experiment Station farm was obtained from that source.

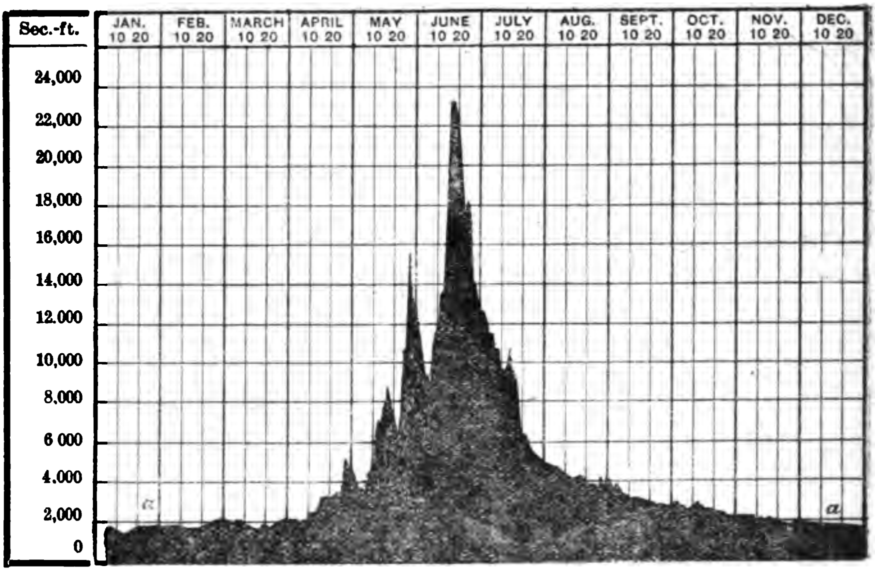


Fig. 6.—Discharge of Yellowstone River at Livingston, Montana, 1898.

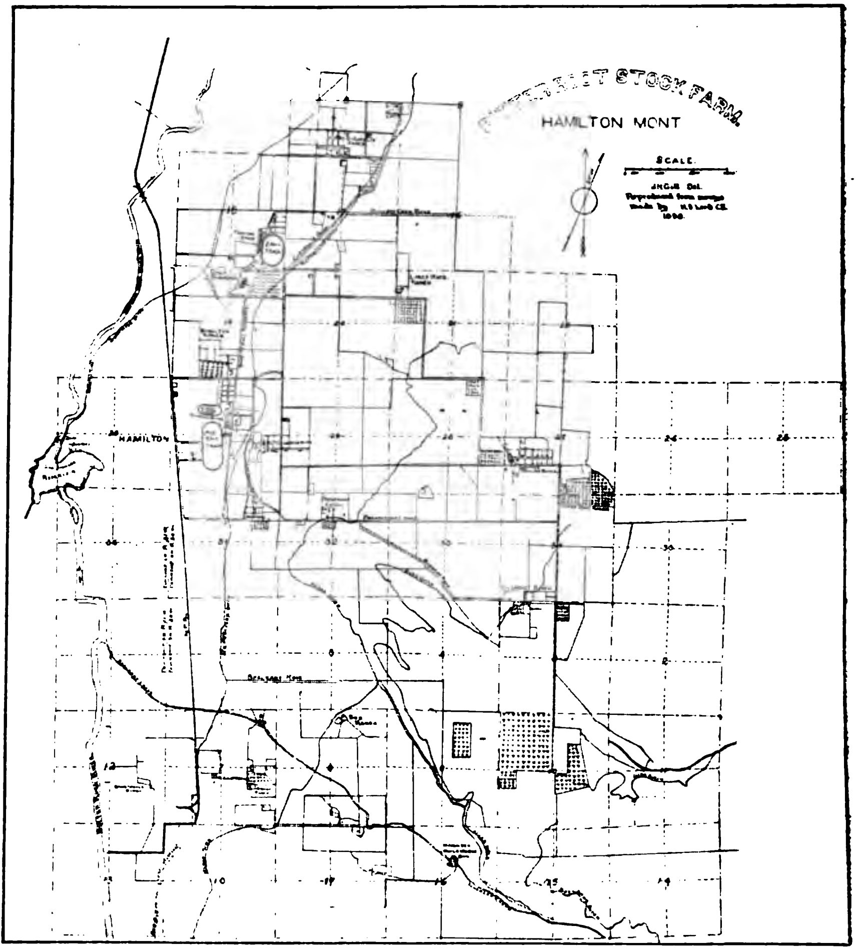


Fig. 7.--Bitter Root Stock Farm, showing canals.

630.679
M9 eb

BULLETIN NO. 30.

UNIV. OF MICH.
JAN 18 1909

MONTANA AGRICULTURAL

EXPERIMENT STATION

...OF...

THE MONTANA COLLEGE OF AGRICULTURE,

WEEDS OF MONTANA.

Bozeman, Montana, June, 1901.

1901.
The Avant Courier Publishing Co.,
Bozeman, Montana.

Montana Agricultural Experiment Station,

Bozeman, Montana.

STATE BOARD OF EDUCATION.

JOSEPH K. TOOLE, Governor JAMES DONOVAN, Attorney General W. W. WELCH, Supt. of Public Instruction	EX-OFFICIO........Helena
J. M. HAMILTON	Missoula
J. P. HENDRICKS	Butte
N. W. MCCONNELL	Helena
O. F. GODDARD	Billings
O. P. CHISHOLM	Bozeman
J. G. MCKAY	Hamilton
G. T. PAUL	Dillon
N. B. HOLTER	Helena

EXECUTIVE BOARD.

WALTER S. HARTMAN, President	Bozeman
JOHN M. ROBINSON, Vice President	Bozeman
PETER KOCH, Secretary and Treasurer	Bozeman
JOSEPH KOUNTZ	Bozeman
E. B. LAMME	Bozeman

STATION STAFF.

SAMUEL FORTIER, Ma. E.	Director and Irrigation Engineer
F. W. TRAPHAGEN, Ph. D., F. C. S.	Chemist
ROBT. S. SHAW, B. S. A.	Agriculturist
J. W. BLANKINSHIP, Ph. D.	Botanist
R. A. COOLEY, B. Sc.	Entomologist

Post Office, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director,

MONTANA EXPERIMENT STATION,
Bozeman, Montana.

The Bulletins of the Experiment Station are sent free to all residents of this State upon request.

Montana Experiment Station.

Bulletin No. 30. June, 1901.

WEEDS OF MONTANA.

J. W. BLANKINSHIP, BOTANIST.

I. GENERAL STUDY OF THE WEED FLORA.

INTRODUCTION.

In the study of the economic features of a new state like Montana, where relatively little has been done toward a systematic biological survey of its natural productions, the botanist is seriously handicapped by the lack of available scientific collections to represent the different species of plants in the state and to show their relative abundance and distribution. Practically all this flora is of economic import, either to benefit or injure the industries of man. The forests are utilized for wood and lumber; the shrubs serve as forest nurseries, the herbs and grasses for forage. Many are capable of economic cultivation for their fruit, for shade or for ornament, while others are harmful and need restraint. Parasitic fungi attack our crops and greatly reduce the yield; many plants are poisonous to stock and cause extensive loss; some ill-flavor the milk of cows or the honey of bees; while the spines of cacti and the awns of grasses seriously injure the mouth of stock, and weeds mar our yards and highways and compete successfully with growing crops.

In order to combat these pests intelligently or to make the best use of the native plants in our industrial life, it is necessary to know their life history, their habits and their distribution within the state, and these facts can be secured only from a representative collection of the species in a herbarium and from the study of the different plants in the field. Without this data, it is impossible to draw accurate conclusions as to the abundance and utility or harmfulness of any economic group. Although much has now been done at this Station toward securing the necessary collections of the native flora and in the study of the economic conditions of the various parts of the state, any present treatment of a large economic group, like the weeds, must of necessity be very imperfect, as large and important sections of the state are nearly unknown scientifically and several large agricultural districts have not been visited.

The study of the weeds of any region must include the sources of infection and the means by which they spread over the country when once introduced, as well as the adaptation of native plants to conditions of tillage and habitation and the means to be adopted for their restraint and eradication. The subject is of special interest in a new state like Montana, where the population is relatively scant and the agricultural districts are widely separated from each other and often from direct weed infection from abroad and where the distribution and composition of the native flora is rapidly changing, owing to the increased settlement and effects of grazing immense herds of stock over the uncultivated portions. It is also desirable to make note of the present status of these weeds in the state in order to observe their future history. Many introduced species are unsuited to our climatic conditions and die out or maintain a precarious existence here, so that they may well be disregarded as a source of danger. Others that appear harmless in the Eastern states may here develop most dangerous habits and require the combined efforts of a community, or even the aid of the state, to check their spread or effect their destruction. It is the object of this paper to present a summary of our present knowledge of the weeds of this state, to indicate the most dangerous introductions and suggest means for their restraint or eradication. It is hoped that farmers, stockmen and others interested, will send this Station specimens of any plant found troublesome or threatening to become a pest in their vicinity, so that the species may be determined, its habits studied and timely warning given to other parts of the state, that prompt steps be taken to effect its extermination should it prove a serious danger. All the plates used are from the Division of Botany of the Department of Agriculture at Washington by whose kindness we are able to give a fair representation of many species which would otherwise be difficult to describe.

GENERAL CHARACTERISTICS OF WEEDS.

Of the various groups of plants troublesome to man, the weeds are of prime importance because of their abundance and general distribution, and from their unceasing struggle with the farmer for the possession of the fields. The *weeds* are that group of troublesome plants, which promptly occupy soil on which the native vegetation has been greatly weakened or destroyed by the operations of man and his domestic animals and which grow and flourish under conditions of habitation, cultivation, travel and pasturage, and occur but rarely removed from these conditions. They are objectionable because they tend to crowd out plants more desirable in our lawns, meadows and pastures, because they render our yards, streets and waysides unsightly and spread thence into our gardens and fields, where they choke out the growing crops and rob them of needful food and moisture, and because their seeds, mixed in the grain used for food by man and stock are unpalatable, or even hurtful. Yet, in most of their characteristics, weeds differ from cultivated plants only in their lack of economic value and their greater hardiness, and the cultivated plants themselves, under favorable conditions, not infrequently escape and become pernicious weeds, like the carrot, radish and turnip in certain sections of the Union.

But there are certain characters and adaptations of weeds, which enable them to grow and spread faster than other plants and give them a peculiar relation to civilized life.

Their habit of occupying lands denuded of their natural vegetation renders them free from all competition except among themselves. They have often wide-spreading basal leaves and spreading or prostrate branches, which enable them to crowd aside other plants, or their vigorous growth permits them to overtop and shade out more slow growing species. They are usually protected against herbivorous animals by growing within fenced enclosures or in streets and lanes, where there is less pasturage. Those found in meadows and pastures are frequently acaulescent (stemless), like the dandelion and plantain, while along streets and highways they are often prostrate, as in the case of pigweed pursley, knotgrass, vervain, carpet weed, and wild tomato, a habit which puts them beyond the reach of most grazing animals. Many have bitter or poisonous secretions or excretions which cause them to be avoided by animals, and others develop spines, prickles or stinging hairs for the same purpose. A considerable number of weeds are able to germinate on and penetrate with their roots the packed soil of street and roadside and to withstand the excessive dryness of the later summer, when many other plants would die under similar conditions.

But one of the most remarkable characters of weeds is their wonderful power of reproduction. Many annuals begin blooming almost as soon as they are out of the ground and produce seed until the frosts of autumn, not rarely going through several generations in a single season, while the number of seeds produced by a single plant often mounts up into hundreds of thousands. With most other plants the season is far advanced before they attain maturity, or their period of fruiting is limited to a short season in early spring and the number of seeds produced is relatively small. The seeds of many weeds are also remarkable for their vitality, and are often able to germinate a dozen or more years after being exposed to ordinary soil conditions, and it is this property which renders the sunflower, wild oat, wild mustard, pigweed pursely, wild tomato, tumble-weed and others so difficult to exterminate when they have once become established. A number of species are more or less fleshy so that they are able to take root again after being dug up, or are at least able to mature the seeds already set, and this habit makes them palatable for stock and thus aids in the distribution of their seed. The large fleshy roots of the dandelion and docks are difficult to kill while the underground stems of the wild morning glory, the Canada thistle, sheep-sorrel. milk-weed, wild liquorice, &c., not only spread the parent plant, but are even aided by the processes of cultivation.

But weeds also labor under certain disadvantages. Nearly all species are desirable food for stock, of which they take advantage to scatter their seeds. By far the larger part are annuals and are hence unable, when left to their own resources, to long compete with the more enduring native species. Biennials are particularly weak, being unfitted for the annual upturning of the soil in cultivation or for extended contests with the perennial species, finding their natural conditions only in waste places and along highways. Weeds must also contend in unceasing passive warfare with man, whose interests they endanger, but who provides them with conditions best suited for their growth.

MEANS OF DISTRIBUTION.

Weeds, like other plants, are dependent upon physical agencies for the distribution of their seed, but rely more largely upon man and domestic animals for this aid. It may be well to enumerate a few of the principal means thus employed.

A considerable number of species depend upon the wind to scatter their seeds and such weeds produce feathery, hairy or winged seeds or have their seed envelopes so modified as to aid in such dissemination. Among these are the thistles, fireweed, dandelion, milkweed, sow-thistle and rag-weed (Erigeron), while the docks, pennycress and orache are likewise assisted by their winged fruit pods and appendages. Again, a group of plants called "tumble-weeds," adapted particularly to the plains, grow in large globular clusters and have the curious habit of breaking loose from the ground in the winter and are then rolled about over the country by the wind, scattering their seeds throughout their course. We have here the tumble-weed (Amaranthus albus), the tumbling mustard (Sisymbrium altissimum) and the Russian thistle (Salsola Kali Tragus), while the tumble-grass (Panicum capillare) is found to some extent eastward.

Another large class depends more particularly upon the water for seed transportation and such seeds have light, water-proof envelopes, which enable them to float for considerable distances before saturation. Indeed, the seeds of nearly all weeds are thus distributed to a greater or less extent, but the sunflower, the horse-weed (Iva), wild mustard, pigweeds and the sweet clover seem to depend mainly upon irrigation for their spread, and the docks come largely under the same class.

A third class requires the agency of animals to assist their migration. Some of these have hooked, barbed or awned fruit which cling to the fur and wool of stock and hence are particularly injurious to the wool industry of the state. Among them may be mentioned the cucklebures, beggar-ticks, wild liquorice, buffalo-bur, spear-grass and foxtail. The weeds so common along streets and highways, in yards and pastures, are distributed mainly by the mud of passage, which adheres to the feet of animals and the wheels of vehicles, while the adhesiveness of a considerable number is further increased by developing a gummy secretion from their outer coat or envelope to assist in the process. These seeds are usually small and frequently depend in part upon water for their extension. Those with mucilaginous envelopes are the plantains, shepherd's purse, bird-seed (Lepidium), Matricaria, Monolepis and Euphorbia, while the sticky contents of the berry of the wild tomato serve a similar purpose. Many of these weeds are edible and have small seeds with impervious coverings, which enable them to withstand the various processes of digestion and they are thus scattered in the offal of animals. Hence barn-yard manure is a prolific source of weeds and always tends to restock our fields with these pests.

But the agencies above enumerated tend only to scatter weeds already established in a community, while foreign species come in chiefly through the agency of man, and it is against these introductions that we are able to guard most effectively. A large number of these imported weeds first reach us through the railways traversing the state, being transported in merchandise, in hay and in the bedding of stock cars and these seeds are dropped en route or in the transfer of goods at the several stations. Hence, it is a matter of common observation that new weeds are frequently first observed along the railways and in the vicinity of such stations. The Russian, the Canada and the Scotch bull thistles seem to arise mainly from this source.

It is probable that the chief means of foreign infection is through the importation of impure seed. New weeds are constantly appearing in our fields and gardens traceable directly to this source and all such weeds should be promptly exterminated before they secure a foothold.

A great part of the weeds of the grain fields, besides providing for independent distribution, ripen their seeds at the same time as the cultivated grains and depend upon the farmer to exercise like care in planting them again. Hence it is necessary, if these weeds be kept out of our fields, that all seed sown be first carefully winnowed, and thus the farmer may later be saved much labor and expense in their extermination, or in the reduced yield from the grain planted. The cockle, sunflower, wild oat, and wild mustard are largely distributed in the seed planted and these are counted among the worst weeds in the state. Garden and lawn seeds are notoriously contaminated and the most troublesome weeds of the East are thus imported, particularly the dandelion, plantain, chickweed, sow-thistle, ragweed, Canada thistle and many others equally troublesome.

ORIGIN OF OUR WEED FLORA.

Some plants in every country acquire the weed habit by adaptation to meet certain conditions, which have resulted in the destruction of the normal vegetation over areas more or less extensive and of fair permanence. Under natural conditions such denuded soil is found in cases of forest fires, landslides and floods. The first two are of infrequent occurrence and the areas effected are soon re-covered, mainly with wind-disseminated species. The floods resulting from melting snows and spring rains are fairly regular in time and permanent in place, so the alluvium deposited each season affords a fertile and permanent ground for the growth and reproduction of the seeds transported in the water. It is these native alluvial weeds, of which the annual sunflower and the horseweed (Iva) are examples, that spread so readily to our fields and gardens with the water used in irrigation and there become permanent pests.

To an appreciable extent, too, weed conditions are afforded by the soil excavated about ant hills, gopher burrows and prairie-dog towns, and here flourish in abundance such species as *Krinitzkia crassisepala*, *Echinospermum Redowskii*, *Plantago Patagonica*, *Malvastrum coccineum* and *Cleome integrifolia*, which now find themselves equally well adapted for growth in yards, streets and waste places. But man in his various pastoral, agricultural and commercial operations, is the chief agent in providing conditions suitable for weed growth.

The occupation of a country by nomadic tribes or a pastoral population essentially disturbs the previously existing balance of native vegetation in that region. The native species are killed about the temporary camps and habitations and the pasturage of flocks and herds tends to reduce or even exterminate many of the more nutritious forage plants and to introduce others, which take the place of those destroyed. A large proportion of the weeds of the Plains probably owe their wide distribution to the Indian and the buffalo, and the stockgrowing industry has merely continued and extended the conditions previously prevailing.

The change in the flora following the settlement of a country by an agricultural population is relatively much greater, owing to the increase of population and the extent of the changes produced by cultivation, travel and commerce which facilitate the introduction of many foreign species.

Thus the weeds of any particular region are of two kinds native (or indigenous) and introduced, the latter coming in from other regions adjacent or remote. It is often desirable to separate these two groups, as it is manifestly impossible to prevent the introduction of species already a component part of our flora, while the foreign species may be prevented from securing a foothold, exterminated, or confined to certain limited sections already invaded.

In the older and more densely populated states it is often difficult to distinguish the introduced plants from the native species without long study and careful comparison over an extended area, and systematic botanists are often lax in this discrimination. In a new state like Montana, the problem is greatly simplified because of the sparsity of settlement and because the sources of weed infection are relatively few and easily traced. Even here many introductions pass as native species by reason of their abundance in certain sections and our uncertainty as to their natural distribution, yet there are certain rules by which we may form a fairly correct judgment as to whether a given species is native or introduced. In general, other conditions being the same, we may infer that a species is introduced if—

1. It is most abundant at the supposed point of introduction, decreases in numbers departing therefrom and is wholly absent in distant or isolated localities.

2. It does not occur in isolated localities growing wild under natural conditions and forming an integral part of the indigenous flora, or is known to be a recent introduction into such localities.

3. It is sporadic in localities widely separated and is much more abundant or occurs in greater perfection in another region from which its introduction may be inferred through known agencies.

4. It is normally found occupying localities in which the native vegetation has been weakened or destroyed by the presence of man and his domestic animals and is rare or lacking in the country adjacent.

The source of its introduction is (1) from a region of its known occurrence adjacent or remote, or (2) from the direction of its greatest abundance in the state, or (3) from the usual source of seed importation into the state, or of travel through it.

Judged by these criteria, the following species may be considered indigenous, although a number (here starred *) by their present restricted distribution in the state and the fact that their bounds are being still extended, indicate that they are of comparatively recent introduction and may best be termed "subindigenes," while a few (†) are doubtful.

I. ANNUALS.

*Amaranthus albus, L.
*A. blitoides, Wats.
*Chenopodium glaucum, L.
*Cleome integrifolia, T. & G.
Draba nemososa, L.
*Dracocephalum parviflorum, Nutt.
*Echinospermum Redowskii, Lehm.
*Euphorbia glyptosperma, Engelm.
*Franseria Hookeriana, Nutt.
*Ellisia Nyctelea, L.
*Helianthus annuus, L.
†H. petiolaris, Nutt.
†Iva xanthiifolia, Nutt.
*Krinitzkia crassisepala, Gray.
*Lepidium apetalum, Wild.
†Monolepis chenopodioides, Moq.
*Plantago Patagonica, Jacq.
†Sisymbrium incisum, Engelm.
*Solanum triflorum, Nutt.

II. BIENNIALS.

Cnicus eriocephalus, Gray.
*Gaura parviflora, Dougl.
*Grindelia squarrosa, Dunal.
*Hordeum jubatum, L.
†Oenothera biennis, L.

III. PERENNIALS.

†Achillea Millefolium, L.
Artemisia Ludoviciana, Nutt,
*Cnicus undulatus, Gray.
Epilobium angustifolium, L.
Gaura coccinea, Nutt,
Glycyrrhiza lepidota, Pursh.
Helianthus Nuttallii, T. & G.
Iva axillaris, Pursh.
*Lactuca pulchella, DC.
*Lepachys columnaris, T. & G.
Lupinus pusillus, Pursh.
Lupinus sericeus, Pursh.
Lygodesmia juncea, Don.
*Malvastrum coccineum, Gray.
Platago Asiatica, L.
*Rumex salicifolius, Weinm.
*Verbena bracteosa, Michx.

This would give the composition of our weed flora as

	Native.	Introduced.	Total
Annuals	19	66	85
Biennials	5	9	14
Perennials	17	16	35
	41	93	134

It thus appears that more that two-thirds of the weeds already noted in the state are of foreign origin and may be kept out of districts in which they are not already established, while, unless preventive measures are taken, the number of such introductions will be greatly increased.

The species enumerated below appear to be extending gradually westward from the Plains.

Allionia nyctaginea, Michx.
Amaranthus albus, L.
A. blitoides, Wats.
Cerastium nutans, Raf.
Cleome integrifolia, T. & G.
Cnicus undulatus, Gray.
Echinospermum Redowskii, Lehm.
Euphorbia marginata, Pursh.
Franseria Hookeriana, Nutt.
Gaura parviflora, Dougl.
Grindelia squarrosa, Dunal.
Helianthus annuus, L.
Iva xanthiifolia, Nutt.
Hordeum jubatum, L.
Krinitzkia crassisepala, Gray.
Lepachys columnaris, T. & G.
Lepidium apetalum, Willd.
Monolepis chenopodioides, Moq.
Panicum capillare, L.
Plantago Patagonica, Jacq.
Solanum triflorum, Nutt.

A few species are coming into the state from the Pacific coast:

Artemisia biennis, Willd.
Chenopodium capitatum, Wats.
Echinospermum deflexum, Lehm.
Epilobium paniculatum, Nutt.
Madia glomerata, Hook.
Madia filipes, Gray.
Matricaria discoidea, DC.
Rumex salicifolius, Weinm.
Sisymbrium incisum, Engelm
Xanthium spinosum, L.

The following, supposed to be natives of tropical America, are now common over much of the Eastern United States, and, with many of the weeds of the plains, are probably our inheritance from the prehistoric American civilizations.

Amaranthus chlorostachys, Willd.
A. retroflexus, L.
Ambrosia artemisiæfolia, L.
A. trifida, L.
Erigeron Canadensis, L.
Solanum rostratum, Dunal.
Xanthium Canadense, Mill.

All the other species enumerated in this paper, with two or three doubtful exceptions, are from the Old World and have reached us mainly from the Eastern States.

THE ROOT SYSTEM.

The root system is of great importance as indicative of the life duration of a species and hence must be taken into account in fixing upon methods for weed extermination.

An *annual* plant germinates, bears fruit and perishes in a single season, while a *biennial* bears only a tuft of leaves the first year and fruits and dies the second. A *perennial* species lives and bears fruit for many years in succession. The roots of annuals are tender and of about the same size as the stem; biennials are usually tender and often thickened and fleshy, but are sometimes difficult to distinguish from annuals, otherwise than by observation, while a number of weeds appear to be either, as emergency requires. Perennials usually have thick, woody, deeply penetrating roots, or long underground stems, or tubers, which enable them to endure indefinitely. The weeds in cultivated ground are mostly rapid-growing annuals, or perennials with fleshy or tuberous roots or rootstocks; those of pastures and meadows are perennials almost exclusively and cannot withstand cultivation.

CLASSIFICATION BY SITUATION.

Weeds may be grouped roughly by means of the localities they affect and the causes that make them objectionable.

I. Weeds of Yards, Waysides, and Waste Places.—These are often tall and unsightly or tend to spread to adjacent fields and gardens. They replace the native plants exterminated by the feet of man and the domestic animals and the wheels of vehicles.

Their seeds usually are spread by the mud of passage or by the wind. The following species may be enumerated as more or less common in these situations:

Amaranthus albus, L.	"Tumble-Weed."
A. blitoides, Wats.	"Pigweed-Purseley."
Ambrosia trifida, L.	"Horseweed" (Eastern.)
A. artemisiaefolia, L.	"Ragweed."
Anthemis Cotula, DC.	"Dogfennel."
Arctium Lappa, L.	"Burdock" (true), rare.
Artemisia biennis, Willd.	"Wormwood."
Atriplex patula hastata, Gray	
Arenaria serpyllifolia, L.	"Sandwort," rare.
Brassica campestris, L.	"Kale." "Wild Mustard."
Brassica nigra, Koch	"Black Mustard;" a rare escape.
Bromus racemosus, L.	
B. tectorum, L.	
Capsella Bursa-pastoris, Moench	"Shepherd's Purse."
Chenopodium album, L.	"Pigweed," common.
C. Botrys, L.	"Jerusalem Oak," common where introduced
C. capitatum, Wats.	"Red Pigweed," westward.
C. hybridum, L.	"Maple-leaved Goosefoot."
Cleome integrifolia, Torr. & Gray	"Indian Pink," frequent in sandy soil.
Cnicus arvensis, Hoffm.	"Canada Thistle," rare.
C. lanceolatus, Willd.	"Scotch Bull Thistle."
Echinospermum deflexum Americanum, Gray	"Beggar Ticks."
E. Redowskii, Lehm.	"Tickseed."
Ellisia Nyctelea, L.	
Epilobium paniculatum, Nutt.	"Cottonweed."
Erigeron Canadensis, L.	"Ragweed," rather infrequent.
Euphorbia marginata, Pursh	
Franseria Hookerania, Nutt.	
Helianthus annuus, L.	"Sunflower," common east of the Divide.
Hordeum jubatum, L.	"Foxtail Grass," common.
Iva xanthiifolia, Nutt.	"Horseweed," common.
Lactuca Scariola, L.	"Prickly Lettuce."
Lepidium apetalum, Willd.	"Birdseed," common.
Madia glomerata, Hook.	"Tarweed."
Marrubium vulgare, L.	"Horehound," infrequent.
Matricaria discoidea, DC.	"Rayless Dogfennel," frequent.
Monolepsis chenopodioides, Moq.	"Poverty Weed," common.
Panicum capillare, L.	"Tumble-grass," frequent eastward.
Plantago major, L.	"Plaintain," infrequent.
Polygonum aviculare, L.	"Knotgrass," common.

Rumex crispus, L.	"Curly-leaved Dock," frequent.
Rumex salicifolius, Weinm.	"Willow-leaved Dock."
Salsola Kali Tragus, Moq.	"Russian Thistle."
Sisymbrium incisum, Engelm.	"Tansy Mustard."
Sisymbrium officinale, Scop.	"Hedge Mustard," infrequent.
Solanum rostratum, Dunal.	"Buffalo Bur," infrequent.
S. triflorum, Nutt.	"Wild Potato," common.
Taraxacum officinale, Weber.	"Dandelion," common.
Tragopogon porrifolius, L.	"Salsify," infrequent.
Urtica gracilis, Ait.	"Stinging Nettle," frequent.
Verbascum Thapsus, L.	"Mullein," in some localities common.
Verbena bracteosa, Michx.	"Vervain."
Xanthium Canadense, Mill.	"Cuckle-bur," infrequent.

II. WEEDS OF LAWNS, MEADOWS AND PASTURES.—These are usually perennial and are obnoxious because they are not only unsightly, but tend to crowd out the more desirable grasses. The seeds of many of these are wind disseminated; some appear to come in with the seed sown. In hay fields they materially injure the quality and selling power of the product.

Achillea Millefolium, L.	"Millfoil, Yarrow." Common.
Cnicus eriocephalus, Gray.	In mountain meadows.
Cnicus undulatus, Gray.	"Thistle." Common.
Grindelia squarrosa, Dunal.	"Rosin Weed." Common in pastures.
Hordeum jubatum, L.	"Foxtail Grass." Common in low ground.
Lepachys columnaris, T. & G.	"Coneflower," pastures.
Plantago Patagonica gnaphalioides, Gray.	"Woolly Plantain." Pastures.
P. major, L.	"Plantain." Troublesome in lawns.
Rumex Acetosella, L.	"Sheep-sorrel."
Taraxacum officinale, Weber.	"Dandelion." Frequent in all situations.

III. WEEDS OF GARDENS AND CULTIVATED GROUNDS.—These are the pests against which the farmers wage incessant warfare, as they tend to crowd out the cultivated plants. By far the greater part of these are annuals, probably importations, recent or remote. Seven are perennials with long creeping rootstocks, all native species (the Canada thistle excepted), while two are often biennials.

A. ANNUALS.

Amaranthus albus, L.	"Tumble-weed." Abundant in loose soil.
A. blitoides, Wats.	"Pigweed-Pursley." Common with the last.

A. retroflexus, L	"Careless Weed." Common in gardens and rich soil.
A. chlorostachys, Willd	Much less frequent; confused with the last.
Artemisia biennis, Willd	"Wormwood." Frequent in many places.
Capsella Bursa-pastoris, Moench	"Shepherd's Purse." Common in gardens.
Chenopodium album, L	"Pigweed." Common in cultivated ground.
C. glaucum, L	A weed not infrequent in gardens.
Cnicus undulatus, Gray	"Thistle."
Draba nemorosa, L	Common.
Erigeron Canadensis, L	"Ragweed." frequent.
Helianthus annuus, L	"Sunflower." One of the worst weeds in the state.
Iva xanthiifolia, Nutt	"Horseweed." Common east of the Divide.
Lepidium apetalum, Willd	"Birdseed."
Monolepis chenopodioides, Moq	"Poverty Weed."
Polygonum Convolvulus, L	"Wild Buckwheat."
Solanum rostratum, Dunal	"Buffalo-bur."
Solanum triflorum, Nutt.	"Wild Potato."
Sonchus asper, Vill	"Sow Thistle."

B. PERENNIALS.

Artemisia Ludoviciana, Nutt	"White Sage."
Cnicus arvensis, Hoffm	"Canada Thistle."
Epilobium augustifolium, L	"Iron-weed." In mountain regions.
Glycyrrhiza lepidota, Pursh	"Wild Liquorice." In low ground.
Lactuca pulchella, DC	"Milk-weed."
Lupinus sericeus, Pursh	"Lupine." Persistent in new ground.
L. pusillus, Pursh	"Little Lupine." Root tuberous.
Lygodesmia juncea, Don	"Wild-asparagus." Plains.

IV. WEEDS OF THE GRAIN-FIELDS.—Mostly annuals fruiting at the same time as the grain; the thistle is a biennial and sheep-sorrel and Gaura are perennial with creeping root-stocks. These from their size, rapidity of growth, or undue multiplication tend to choke out the grain in which they grow and are difficult to repress on account of the fact that, after seeding, about the only way to get at them is by hand-pulling, a slow and expensive process.

Avena fatua, L	"Wild Oats." Common all over the state.
Brassica Sinapistrum, Boiss	"Wild Mustard." Very bad in many localities.
Bromus secalinus, L	"Cheat." Troublesome in some places.
Camelina sativa, Crantz	"False Flax."
Cleome integrifolia, Torr. & Gray	"Indian Pink."

Euphorbia glyptosperma, Engelm	"Spurge."
Gaura coccinea, Nutt	
Helianthus annuus. L	"Sunflower.'
Iva xanthiifolia, Nutt	"Horseweed."
Lactuca pulchella, DC	"Milkweed."
Rumex Acetosella, L	"Sheep Sorrel."
Polygonum Convolvulus, L	"Wild Buckwheat."
Saponaria Vaccaria, L	"Cockle."

II. PRACTICAL CONSIDERATIONS.

METHOD OF ERADICATION.

1. Crop Rotation—It will be seen from the foregoing lists that our weeds, troublesome in cultivation, fall naturally into three groups: (1) weeds of grain fields, (2) of meadows and (3) of cultivated ground and that our yards, roadsides and waste places are the chief sources of local infection. The natural method for the suppression of weeds then must be by crop rotation, as the growth of one kind of crops tends to restrain or destroy the weeds peculiar to the other two groups. Therefore, when our grain fields become foul with the sunflower or wild oats, they should be put in timothy, alfalfa or clover till the weeds have been crowded out; or the land may be cultivated in some root crop like potatoes, rutabagas, &c., and the weeds destroyed by frequent cultivation. Unfortunately, here in Montana, the climatic conditions limit this crop rotation almost to cereals and hay-lands, as maize can be grown profitably in but few parts of the state and root crops and garden truck can not be planted over any great area, on account of the expense and labor involved and the certainty of swamping the market.

2. Summer Fallow.—Where it is desired to grow a grain crop as continuously as possible, it is hardly profitable to seed down in timothy, alfalfa or clover for a single year, and, as extensive cultivated crops, such as are grown in the Mississippi valley, are not here feasible for the reasons stated, in many parts of the state a system of summer fallow has been adopted, which consists usually in plowing under the weeds late in May or June before they have matured and then going over the soil once or twice afterwards with a disk or cultivator to prevent the new growth attaining any size. This effectually reduces the growth of the annual weeds so troublesome to grains and materially increases the fertility of the soil, but the loss of income from the fallowed land and the expense of cultivation, far offset any advantages thus derived, while, unless the land is disked after plowing, it is often worse seeded in weeds than before. It is much more profitable either to seed down foul wheat lands in some hay crop or in grain suitable for pasturage and thus secure some return from the land while the weeds are being killed.

3. Pasturage. There are some weeds like the sunflower, wild oats, and wild mustard, which are very difficult to clear out of land, when once they have a good foothold. For such weeds, and other of like nature, a very effective and profitable method of eradication is to sow the land down in some grain suitable for pasturage, such as rye or oats, or in clover or mixed grains, and to keep this closely cropped by sheep, so that no weeds that come upwill have any chance to mature seed. Two or three years of successive pasturage in this manner should effectually clean the worst infested lands. Other kinds of stock will do, but they are more prone to exercise selection and permit the growth of the less edible varieties. Sheep clean off all alike.

4. Special Methods.—In some cases special methods may be employed with advantage. Hand-pulling is frequently possible in small fields or patches of grain infested with the sunflower, wild mustard, tumbling mustard, etc. This may be done by boys under competent supervision, and is best undertaken when the weeds first come well into bloom and before they have matured any seed. The bright yellow flowers serve as guides to the location of each individual and their absence clearly marks the strip

cleared. The work should not be left till the seeds begin to mature, else it will be necessary to remove the plants pulled to prevent them from re-seeding the ground cleared. This method is slow and expensive, especially here in Montana where labor is such a desideratum, and it can rarely be employed with economy.

In a few instances hand weeding is practically the only method available. This will apply particularly to weeds affecting lawns and meadows. The broad-leaf plaintain can only be dug up one plant at a time, and this is also true of the dandelion and thistles, but with the last two a chisel-like instrument ("spud") with a four foot handle may be employed to cut them off just below the crown of leaves and is usually found effective.

There are a few species of weeds which are particularly difficult of extermination on account of the spread of underground stems. A few of our native species exhibit this tendency to a greater or less extent, such as the Poverty Weed (Iva axillaris), the Wild Liquorice (Glycyrrhiza lepidota), the Milk-weed (Lactuca pulchella), the Wild Asparagus (Lygodesmia juncea), the Iron-weed (Epilobium angustifolium), and the Lupine (Lupinus sericus), but these usually disappear after a few years cultivation and persist only in specially favored localities, where they may be treated like the next. But it is from a few foreign introductions that the chief trouble arises and these should be exterminated before they have become firmly established. The Canada Thistle is the worst and a law has been enacted to enforce its destruction in the state. It is established in many places along the railroads and is frequently imported with garden seed. It is found only in small patches and appears to show little disposition to spread by seed in this state. The most effective method to get rid of it is probably to dig it up, removing every particle of the root-stocks and then await growth to indicate the location of any root remnants in the soil. Its growth can be restricted by keeping it cut down, but this will scarcely exterminate it. It can be smothered out by building straw or haystacks over the spots affected, or by covering with manure dumps, and it may often be killed by plentifully sprinkling salt or kerosene over the freshly cut stumps. Sodium arsenite is more effective, but also more expensive.

The wild Morning-glory (Convolvulus arvensis) and the Sheep-sorrel (Rumex Acetosella) are nearly as difficult to eradicate and much worse to spread than the Canada thistle, but fortunately they have as yet appeared in but few localities in the state. They should be treated in much the same way as the Canada thistle above. For lawn weeds which tend to spread and crowd out the grasses, such as dandelion, plantain, chickweed (Cerastium vulgare), rosin-weed (Grindelia squarrosa) and others of like nature there is nothing we can do more than to dig them up by hand, or treat them with chemicals, which also will kill the grass around. The process is slow but the areas affected are usually not large. Walks and driveways can be kept clear by the aid of salt, kerosene, arsenite of soda, or some of the various chemicals sold by seedsmen. Much time and labor can be saved, if it be remembered that the streets, roadsides and waste places are the natural storehouses for the growth and propagation of weeds and that these places must be kept clear, or at least the weeds must be kept from seeding in them, if the yards, gardens and fields adjacent are to be free from these pests.

The Russian thistle, of which so much has been said and written, does not appear to exhibit such dangerous characteristics in this state. I have found it nowhere in any abundance except in the Milk River and Yellowstone valleys, and there as well as in all other places observed it is confined to the railway grades and waste places about the towns. It makes no headway against the native vegetation and has not yet, in any case noted, invaded cultivated land. Nevertheless, its wide advertisement as a most dangerous pest must be based upon its tendency to invade grainfields and cultivated ground and it is comparatively little trouble to prevent it from securing a footing in any locality, if taken when it first appears and every plant be uprooted, piled and burned. It is possible that it may yet prove a valuable forage plant for the arid regions, and instead of a most dangerous, immigrant, it may prove a valuable addition to our native vegetation.

The Scotch bull thistle is not nearly as dangerous as the dandelion and sheep-sorrel, the wild oats, the wild mustard, tumbling mustard and the sunflower. It is very rare in the state, occurring mostly about railway stations and towns, in no considerable quantity except in the Flathead valley in the vicinity of Demersville, where it has proven a dangerous pest. It should be dug up or cut off below the crown of the root before it blooms. It is not a perennial like the Canada thistle and only needs to be kept down for a year or two and prevented from seeding. It should not be allowed to become established in any locality and any person permitting it to grow on his land should be prosecuted under the law now in force.

A great difficulty in the extermination of weeds is the fact that the seeds of many species will lie in the soil for several years without losing their vitality and when turned up to the surface will germinate and produce a new crop of weeds in ground which is considered cleared. It is for this reason that several years of diligent culture is necessary before a field can be cleared of such weeds as the sunflower, wild oats and wild mustard and it is for this reason that summer.fallow, unless followed by cultivation, will result in seeding the field with weeds more than before. A field can not be cleared of noxious weeds until all the seeds can be caused to germinate and then killed.

There is no question but that the injury done the growing crops in this state by the growth of weeds amounts to many hundred thousand dollars every year and yet there is no systematic method devised for their eradication. Each man tills his own fields with little regard to the growth and distribution of weeds from infected localities; and no combined attempt is made to stamp out the pests in such affected areas. If we treated contagious diseases it this way, it would be utterly impossible to stay the deadly epidemics. Isolation and united effort is made against such diseases in every community, and a similar effort against weeds would certainly be successful in this state, where the agricultural communities are naturally more or less isolated from each other.

The only feasible method then for combatting weeds in Montana where few of the more dangerous and troublesome species have yet more than secured a foothold, is by the organization of the farmers into districts designated by the valley or irrigation system and the appointment or election of a competent weed inspector for each district, whose duty it shall be to keep a lookout for the appearance of any new or dangerous weeds in his district and to cause the eradication of such pests as may already be established, and this inspector shall have similar powers to road supervisors to call for a certaim amount of aid from each farmer to be used in the common interest of stamping out these pests from infected localities, or to compel individuals to clear their lands of such pests.

It would thus be possible to hold one man responsible for keeping down these noxious weeds, while now the responsibility is fixed upon no one and the interests involved are certainly as great, if not greater, than in the maintenance of a good road system. It should also be made the duty of the road supervisors to keep the weeds cut or plowed under along the different public highways within their jurisdiction. Unless some effort of this kind is soon made, the labor of the farmer will be greatly increased.

THE WEED LAW NOW IN FORCE IN MONTANA.

[PENAL CODE, APPROVED MARCH 18, 1895.]

"§1197. Be it enacted that the weeds known as the Canada thistle, the Scotch bull thistle and the Russian thistle are hereby declared to be a common nuisance for all the purposes of this Act.

§1198. Any person or persons owning any lands within this State, or occupying or having control of any lands, whether within the plat of towns, villages or cities, or otherwise, within this State, knowingly permitting or suffering any Canada, Scotch bull or Russian thistle or thistles to go to seed upon any land or lands thus owned, occupied or under control of such person or persons shall be deemed guilty of supporting and maintaining a common nuisance, and upon conviction thereof in any court of competent jurisdiction, of the offense, shall be punished by a fine not exceeding fifty nor less than five dollars.

§1199. In case any person or persons, railroad or other corporation, owning or occupying any lands within this State, under his or her or their control, as the case may be, shall refuse or neglect to destroy any Canada, Scotch bull or Russian thistle or thistles growing or standing upon any land or lands so owned, occupied or controlled, on or before the fifteenth day of August, it shall be the duty of the county commissioners, road supervisors, or other person or persons having control of the public highways, streets or alleys where any such thistle or thistles may be found growing or standing, to immediately destroy or cause the same to be destroyed, and pay therefor at the same rate that is paid for road labor; and every supervisor or other person hereinbefore authorized to destroy said thistles shall keep a correct account of all moneys paid out for that purpose, and charge the same to the person or persons or corporation owning, occupying or controlling the land or lands upon which such thistle or thistles were destroyed, and the person or persons or corporation owning, occupying or having control of such lands shall be liable in a civil action for the amouut so charged against them and costs of suit;

Provided that if any supervisor or other person having, under authority of this Act, destroyed any of the said thistles, and is unable to find the owner of the land, or is unable to collect such money, the same shall be paid by the authorities of the town, village, city or county where such thistles were destroyed; *and provided further*, that in case any railroad company becomes chargeable under the provisions of this Section, the supervisors of the township where same has become chargeable may certify to the same to the county attorney of their county, whose duty it shall be to bring and prosecute a civil action against the railroad company for the amount so charged and costs of suit aforesaid.

§1200. It is hereby made the duty of every person having knowledge of any Canada, Scotch bull and Russian thistle or thistles growing or standing upon the lands of another to immediately destroy the same, or give the person owning or occupying such lands immediate notice thereof."

III. ANNOTATED LIST OF MONTANA WEEDS.

In order to note the introduction and spread of weeds in this state, and to give the farmer some idea as to the names of the weeds troublesome in any particular locality and facilitate their destruction, if dangerous, the following enumeration of the known weeds of Montana, with brief popular descriptions of the more troublesome species and notes of their origin, occurrence and dissemination is appended. In case of doubt, specimens of any weed with flower or fruit and leaves should be sent this Station for determination.

In a general work of the nature of this bulletin, it seems desirable, in the main, to use the older, more conservative nomenclature and to adopt the wider limitation of species, not necessarily because they are better or more accurate, but because they are more easily understood by the ordinary reader and are more readily found in the usual works of reference. For the same reason technical terms have been avoided as far as possible, and the popular names of plants have been employed wherever it could be done without ambiguity. Yet, as common names are frequently used here, for two or more very different species, or for different plants in other sections of the Union, as in the case of the pursely, cucklebur, horseweed, ragweed, milkweed, ironweed, povertyweed, &c., it is necessary to make the scientific name the basis of classification and description. Hence the plants hereafter enumerated are arranged alphabetically according to their scientific names, but the index of popular names appended will enable these to be used with equal facility.

A few terms need explanation. Flowers and fruit are arranged in a *spike* when they form a close slender column like those of the plaintain and timothy; they form a *panicle* when they are scattered on slender stalks, like the oat, and they are called a *head* when they are aggregated in a dense cluster, as in the case of the clover and the sunflower.

In the list below the weeds most troublesome in the state are printed in **black letter** and the rare introductions are starred (*).

1. ACHILLEA MILLEFOLIUM L. Wild Tansy; Milfoil.

A perennial plant about two feet high with finely divided leaves and white flowers in a level-topped cluster. Frequent in pastures and meadows, where its bitter herbage makes it distasteful to stock.

2. AGROSTEMMA GITHAGO, L. Corn Cockle.

A purple-flowered annual occasional in grain fields, but hardly troublesome here, as it is in the East. Noted in but few localities. It has narrow leaves and fewer and more scattered flowers than is the case with the ordinary cockle (Saponaria Vaccaria) and is silky hairy throughout.

3. ALLIONIA NYCTAGINEA, Michx.

A tall (2 to 4 feet high), smooth, much-branched perennial with heart-shaped opposite leaves and clustered purplish flowers. Occurs as a weed in gardens in the extreme eastern part of the state (Calais and Wibaux) and promises to spread westward.

4. AMARANTHUS ALBUS, L.

Tumble-weed.

A widely-spreading annual weed, common in loose or cultivated ground. It begins blooming in early spring and produces seed all the season. It is killed down by the first heavy frost and the large globular mass breaks off from the root and is driven about by the wind, scattering its seeds throughout its course. Apparently native east of the Divide. Hybridizes with the next. [Fig. 1].

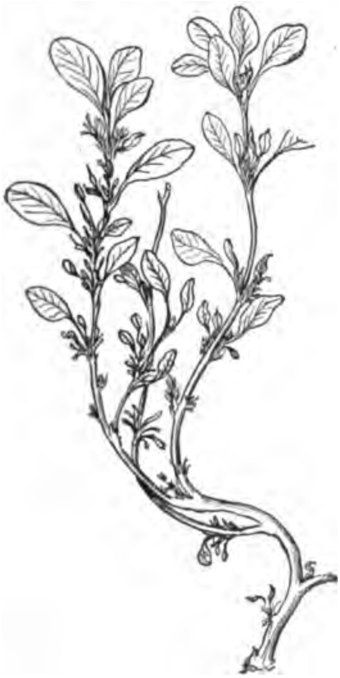


Fig. 1. Amaranthus albus, L. Branch ½ natural size.

5. AMARANTHUS BLITOIDES, Wats. PIGWEED-PURSLEY.

A prostrate-growing, reddish annual, closely related to the preceding and much resembling the eastern "purseley" (Portulaca oleracea, L.) Common in waste places and roadsides east of the Divide and not infrequent as a weed in cultivated ground. Forms mats sometimes three feet in diameter; apparently native.

6. *AMARANTHUS CHLOROSTACHYS, Willd. PIGWEED.

Closely resembling the next in habit and appearance and popularly confused with it, but its fruiting spikes are long and slender and it is much more rare in gardens and waste places. At Columbia Falls and Troy; here apparently coming in from the West.

7. AMARANTHUS RETROFLEXUS, L. PIGWEED; CARELESS WEED.

A fleshy annual common in our gardens and imported from the East in garden seed; shows little tendency to spread to fields except in rich and moist situations. These four species of amaranth are easily uprooted and should not be allowed to seed in our gardens. They should be piled, dried and burned to prevent the seeds matured from re-seeding the ground from which they have just been removed.

8. AMBROSIA ARTEMISIÆFOLIA, L. RAGWEED; HOGWEED.

An annual weed, one or two feet high, with opposite many-divided leaves and slender, green-flowered terminal spikelets. This is now coming in from the East along the railways. Frequent on the Great Northern from Havre eastward and occasional as far west as Kalispell. Often abundant in waste places, but with little disposition to take to fields and gardens.

9. AMBROSIA PSYLOSTACHYA, DC. CREEPING RAGWEED.

Occurs occasionally in the eastern part of the state, but has not yet been found very troublesome. It is very similar to the one above, but has long perennial rootstocks which make it difficult to eradicate.

10. AMBROSIA TRIFIDA, L. Horseweed; Tall Ragweed.

A large annual with opposite three-lobed leaves and flowers very similar to the two above. It is here rarely more than two or three feet high, and is found occasionally with leaves entire. Like A. artemisiæfolia it is coming in from the Mississippi valley along the railways and is found principally in waste land about the stations, but in low situations is spreading to adjacent fields and gardens. Extends as far west as Havre and Savoy on the Great Northern and to Bozeman on the Northern Pacific. Infrequent except eastward. Seeds disseminated by water and in mud. [Fig. 2.]

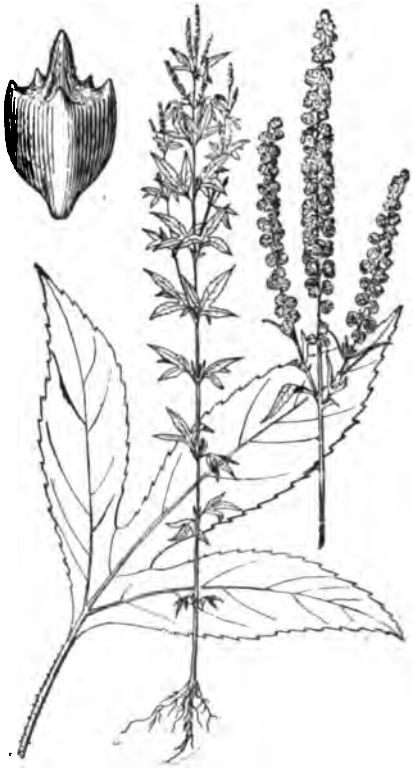


Fig. 2. Ambrosia trifida, L.

11. ANTHEMIS COTULA. DC.

Dog Fennel; Mayweed.

An annual ill-scented weed about a foot high, with a level-topped mass of white-rayed flowers; leaves alternate and finely divided. Not infrequent in waste places in nearly every part of the state and shows some disposition to spread and become troublesome as it does in the more humid climate of the eastern states.

12. *ARCTIUM LAPPA, L. Burdock.

A coarse biennial about three feet high, with large leaves and purple flowered heads disposed in a many-branched terminal panicle each surrounded with a bur-like involucre. A European introduction common in the eastern states, but noted here only at Libby, Thompson Falls, Plains and Big Timber, along roadsides and in waste places, where it shows a strong disposition to spread and become troublesome to the sheep industry.

13. *ARENARIA SERPYLLIFOLIA, L.

A small, inconspicuous annual two or three inches high, or prostrate, of European origin, well established about the streets and waste places at Columbia Falls, but not otherwise noted in the state.

14. ARTEMISIA BIENNIS, Willd. WORMWOOD; IRONWEED.

An annual or biennial coming in from the west, two or three feet high, with a slender, reddish stem, finely divided leaves and a narrow terminal spike-like panicle of inconspicuous flowers. Becoming common in streets and waste places about the larger towns and thence spreading to the highways and neighboring fields, where it is beginning to be a troublesome pest.

15. ARTEMISIA LUDOVICIANA, Nutt. WHITE SAGE.

A native perennial sage with long creeping rootstocks which tend to persist in new ground and meadows and is often difficult to eradicate.

16. *ATRIPLEX HORTENSIS, L, ORACHE.

Escaped from cultivation, particularly the ornamental variety *atrosanguinea*, Hort. Not infrequent in yards and waste places about Helena and Bozeman, but not likely to become troublesome. An annual much resembling its relative the Lamb's-quarter.

17. ATRIPLEX PATULA HASTATA, Gray.

An annual much resembling and often confused with Lamb's Quarter; occurring along streets and in waste places; apparently introduced from the East. Occurs occasionally in nearly every part of the state but is rarely troublesome in cultivated ground.

18. AVENA FATUA, L. WILD OATS.

This is one of the most common, if not the worst weed in the state. Introduced from the Old World, but now common throughout most parts of arid America where oats have been cultivated. The wild oat differs from the cultivated variety in its usual ranker growth, deeper color of the foliage, more diffuse panicle, earlier

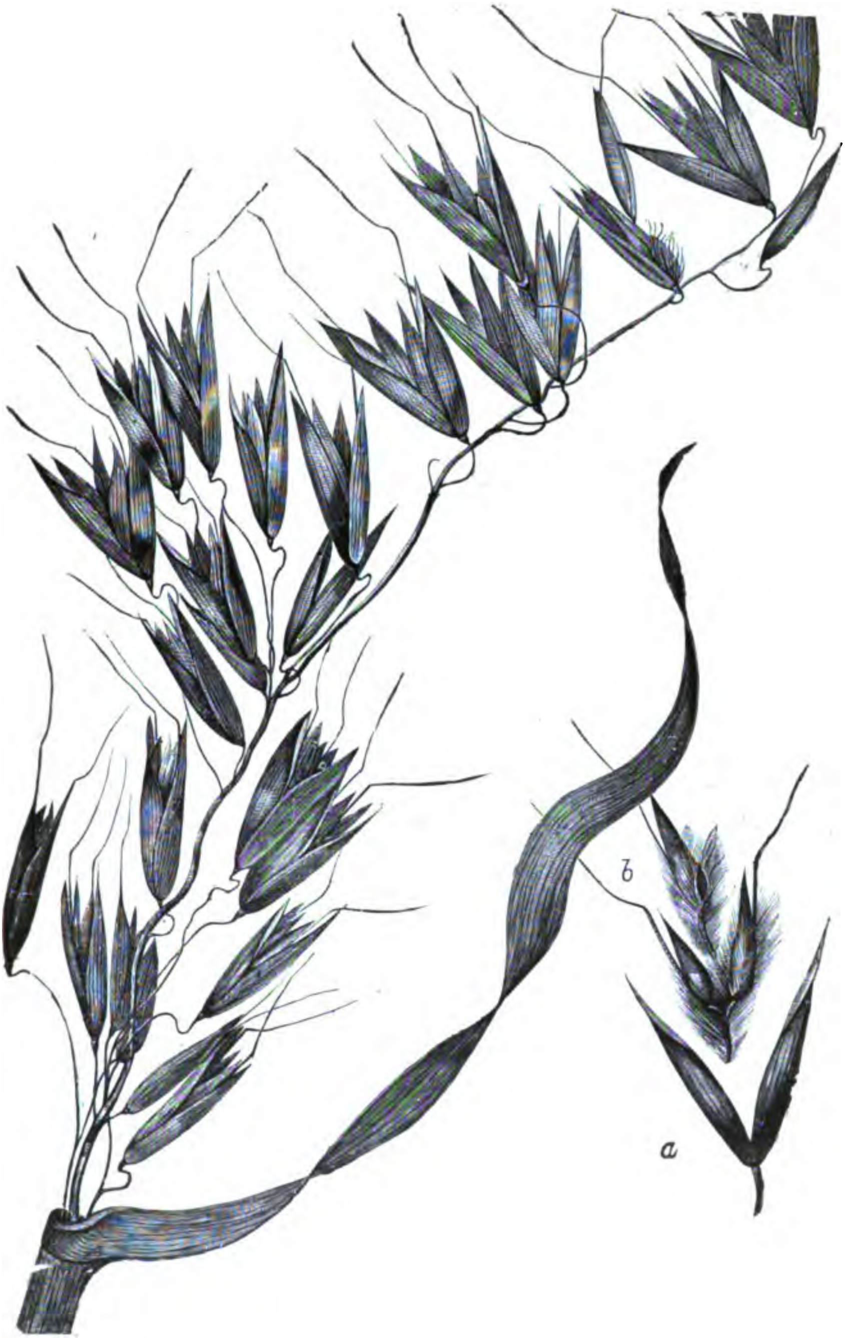


Fig. 3. Avena fatua, L. Fruit, natural size.

ripening and prompt shelling of the fruit, its black hull (flowering glume), hairy at base and with a twisted awn and in its smaller and lighter seed. Its fecundity, rapid growth and self-seeding qualities soon enable it to take a field sown continuously in any kind of grain and the persistent vitality of its seed in the soil makes it difficult to eradicate. It can best be combatted by sowing down infested fields in clover, timothy or alfalfa, or by close pasturage by sheep for several years of such fields, planted in some annual grain suitable for forage. There is a general belief among farmers that the wild oat often originates as a degenerate form of the cultivated variety with which it seems to intergrade, and, while it is propagated in general from its own seed, its general occurrence and abundance in fields sown in oats throughout the arid region seems to favor the idea of such reversion. Moreover, the cultivated oat is supposed to have been derived from the wild species, and several authenticated instances are known of the production of the tame varieties from the wild form by cultivation and reversion under suitable climatic conditions is much more probable, as is certainly the case with many other cultivated plants, such as the radish, carrot, turnip, mustard and parsnip, which in many places readily revert to the wild form and become troublesome weeds. [Fig. 3.]

19. **BRASSICA CAMPESTRIS** L. KALE; WILD TURNIP.

An annual closely resembling and usually confused with the wild mustard (Brassica Sinapistrum, Boiss.), but is smooth throughout and is rarely so common or troublesome as the latter species, though occasionally found in grain fields and waste places. Its smooth, bluish stem and upper leaves, sessile and clasping, easily distinguish it from the two below.

20. *BRASSICA NIGRA, Koch. BLACK MUSTARD.

An occasional escape from gardens, but nowhere troublesome or difficult to restrain. Rarely persistent.

21. **BRASSICA SINAPISTRUM**, Boiss. WILD MUSTARD; CHARLOCK.

Resembling the B. Campestris above, but is more or less hairy throughout. One of the worst weeds of the state, fairly taking many of the grain fields in low land. Should be combatted like the wild oat and the sunflower. Hand pulling may be employed when it occurs only in small patches. Every effort should be made to prevent its introduction into a community and combined action should be taken to clear infested fields, as the seeds appear to be spread largely by irrigation. [Fig. 4.]

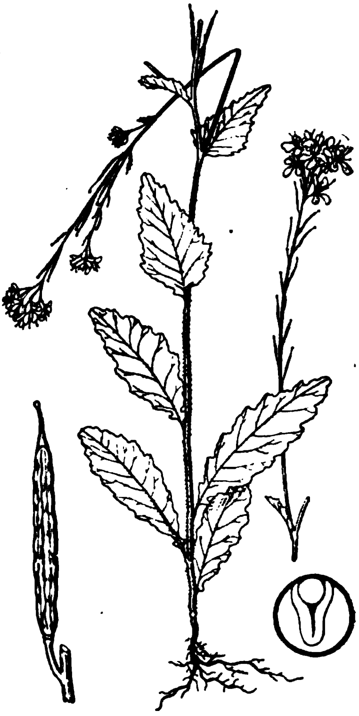


Fig. 4. Brassica Sinapistrum, Boiss, ¼ natural size.

22. BROMUS RACEMOSUS, L.

An annual Brome-grass not infrequent as a weed in fields and waste places; commonly confused with the next, which it closely resembles.

23. BROMUS SECALINUS, L. CHEAT; CHESS.

Differs from the last in its more diffuse panicle and its larger and flatter spikelets. Not rare in agricultural districts of the state and often a very bad weed in grain fields in the Flathead valley.

24. *BROMUS TECTORUM, L. DOWNY BROME-GRASS.

A small annual grass with long-awned pendulous spikes well established at Columbia Falls and Missoula, in streets and waste places and promises to spread into other parts of the state. Introduced from Europe.

25. **CAMELINA SATIVA**, Crantz. FALSE FLAX.

An annual with light yellow flowers and a pear-shaped pod of the Mustard family and resembling somewhat the cultivated flax. A frequent and occasionally troublesome weed in grain fields throughout the state. Usually imported in the grain seed sown.

26. **CAPSELLA BURSA-PASTORIS,** Moench. SHEPHERD'S PURSE.

A common annual of yards, gardens and waste places. Blooms throughout the season. A foot or two high with white flowers and a triangular pod. A European introduction. Seeds develop a mucilaginous coat when wet and thus facilitate their dispersion.

27. *CERASTIUM NUTANS, Raf.

A small inconspicuous chickweed with sticky foliage and curved pods notched at the orifice. Occasionally introduced from the East. In waste places infrequent.

28. *CERASTIUM VULGATUM, L. MOUSE-EAR CHICKWEED.

Found very troublesome in lawns at Kalispell, where it forms patches and crowds out the grass and its perennial habit makes it difficult to exterminate, except by digging up and removing every plant. Also in waste places at Thompson Falls and Borax; coming in from the West.

29. **CHENOPODIUM ALBUM,** L.

LAMB'S QUARTER.

A common and troublesome annual in waste places and cultivated ground in nearly every part of the state. It fairly takes uncultivated fallow land in many localities. An Old World species. [Fig. 5]

30. *CHENOPODIUM BOTRYS, L.

JERUSALEM OAK.

A bitter, ill-smelling annual from Europe locally established in waste places at various points in the state, and seems well adapted to our climate. Resembling the preceding species in size and appearance, but the leaves are more deeply lobed.

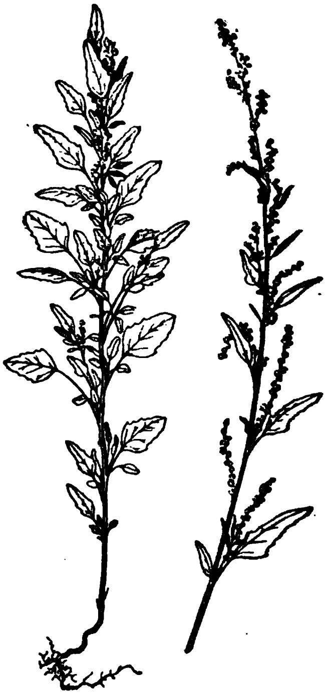


Fig. 5. Chenopodium Album, L. ⅛ nat. size.

31. CHENOPODIUM CAPITATUM, Wats. STRAWBERRY BLITE. RED PIGWEED.

An annual weed in yards and waste places coming from the west along the railways; rare east of the Divide. Somewhat like the Lamb's Quarter, but the fruit is in red globular clusters resembling the strawberry.

32. CHENOPODIUM GLAUCUM, L. OAK-LEAVED GOOSEFOOT.

A prostrate or spreading annual much resembling the Poverty-weed (Monolepis chenopodioides), frequent in low grounds by roadsides, in alkali places and occasionally troublesome in gardens and cultivated ground. Possibly native here, although it has the habit of a true weed.

33. CHENOPODIUM HYBRIDUM, L. MAPLE-LEAVED GOOSE-FOOT.

Another of the introduced Pigweeds, two or three feet high and with a widely spreading panicle of fruit, found occasionally in waste places about the towns along the railroads. Its leaves have little resemblance to those of our native maple. It is probably truly indigenous nowhere in America.

34. *CHRYSANTHEMUM LEUCANTHEMUM, L.

OX-EYED DAISY.

A European perennial found troublesome in the Eastern states. Apparently persistent in meadows here in a few isolated localities in small numbers, and showing no disposition to spread. Imported in grass seed from the East.

35. *CICHORIUM INTYBUS, L. Chicory.

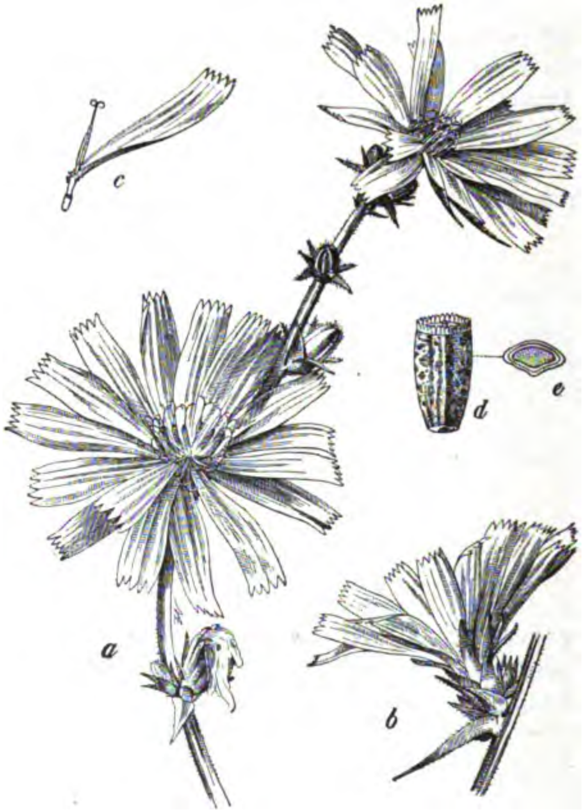


Fig. 6. Cichorium Intybus, L. Flower natural size.

A tall, widely branching European perennial with large blue flowers which close in the afternoon, related to and somewhat resembling the lettuce. A few specimens seen near Holt, in the Flathead region; but observed nowhere else in the state. This weed is adapted to growth in dry situations and should not be allowed to become established in the state, lest it become a dangerous pest. [Fig. 6.]

36. **CLEOME INTEGRIFOLIA**, Torr & Gray.

INDIAN PINK; STINKWEED.

A native annual about two feet high with 3-foliate leaves and pink flowers, often troublesome in sandy soil. Frequent in grain fields and waste places east of the Divide and now spreading westward along the railways, where it threatens to become a bad weed.

37. **CNICUS ARVENSIS**, Hoffm

CANADA THISTLE.

A perennial European species with long creeping rootstocks most difficult to extirpate. Very similar to our native thistles, but the heads are much smaller and the plants tend to grow in clumps or patches, never scattered. Infrequent as yet in the state but becoming established along railroads and in waste places. Occurs at Helena, Bozeman, Libby, Craig and Demersville. Can be eradicated only by persistent digging, by smothering with straw, manure heaps, &c., or by choking out with a rank growth of clover. Attack on first appearance and do not permit it to become established. One of the three plants outlawed in this state. [Fig. 7.]

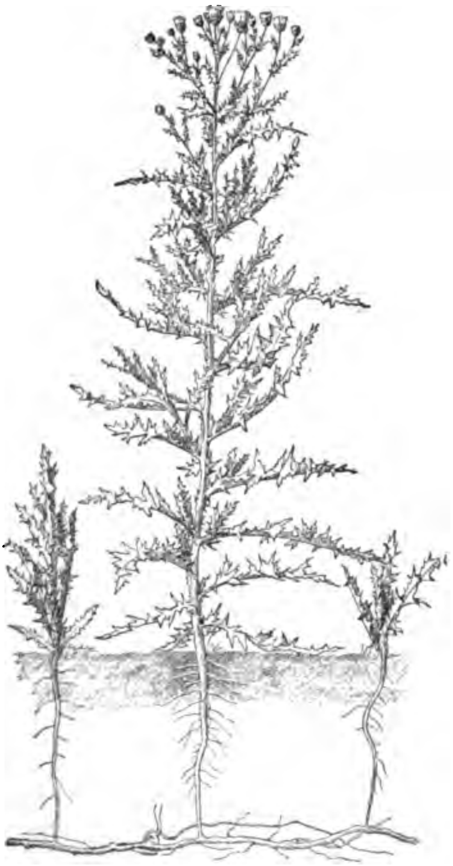


Fig. 7. a. Cnicus arvensis, Hoffm. Plant one-fifth.

38. CNICUS ERIOCEPHALUS, Gray. MOUNTAIN THISTLE.

A tall unbranched thistle with a mass of heads aggregated at the top of a thick, hollow, leafy, stalk, frequent in mountain meadows and pastures above 5,000 feet altitude. Rarely so abundant as to be troublesome.

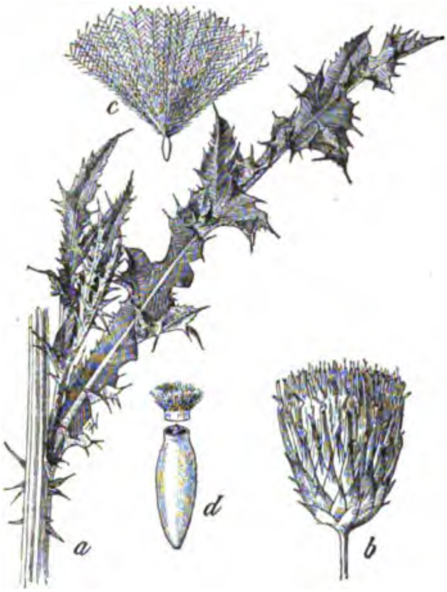


Fig. 7. b. Cnicus arvensis, Hoffm. Leaf and head about natural size;

39. CNICUS LANCEOLATUS, Willd. SCOTCH BULL THISTLE.

The second outlawed weed of the state. A European biennial sparsely introduced along the railroads of the state, but nowhere observed to be troublesome except in the Flathead valley about Demersville. It is easily destroyed by digging up the plants before they bloom and should not be allowed to secure a foothold. The plant is very similar to our native thistle described below, but has much less of the cottony tomentum on the under side of the leaves and the leaves and heads are exceedingly prickly with long yellow spines. [Fig. 8.]

40. CNICUS UNDULATUS, Gray. FIELD THISTLE.

The common thistle of the plains and valleys throughout the state and troublesome in many places, particularly in fallow land, old fields, pastures and meadows, replacing C. eriocephalus below 5,000 feet; biennial, or sometimes apparently perennial with deeply penetrating roots. A tall, branched thistle with scattered heads and leaves covered with a dense cottony tomentum.

41. *CONVOLVULUS ARVENSIS, L. WILD MORNING-GLORY.

A European perennial vine similar to the cultivated morning-glory, but with small white flowers; occasionally established in gardens and waste places; quite as difficult to exterminate as the Canada thistle and should be treated like it. Noted at Manhattan, Helena, Missoula, Flathead Lake, Kalispell, Bozeman and Crow Agency.

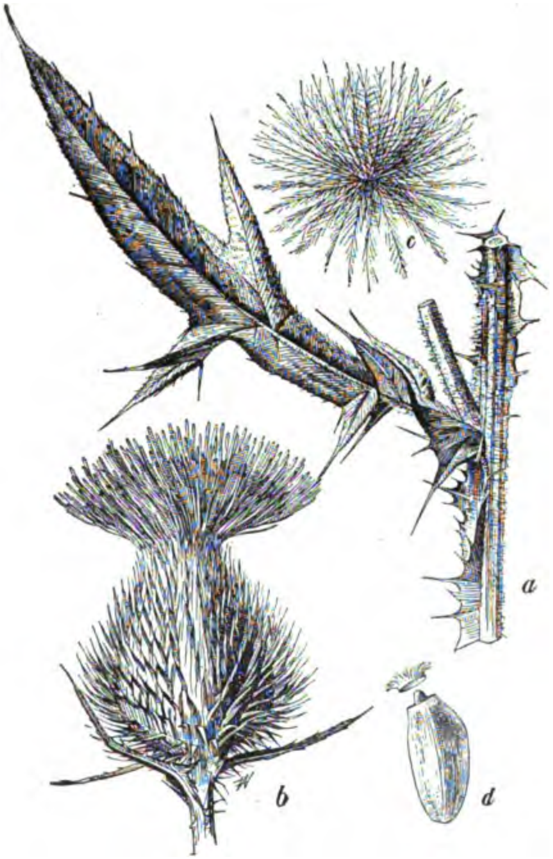


Fig. 8. Cnicus lanceolatus, Willd. Leaf and head natural size.

42. *CUSCUTA EPITHYMUM, Murr. Alfalfa Dodder.

Specimens of this species have come in from Livingston reported as troublesome in alfalfa fields. It is a golden yellow parasitic vine on alfalfa and the clovers; imported from Europe, where it is often a most pernicious weed. The infested spots should be mowed closely and the plants burned when dry; they should not be allowed to seed as it may be difficult to clear the field of the parasite. A native species of dodder (*Cuscuta arvensis*) also occurs sparingly on the clovers and alfalfa in this state, but is not apt to take the fields like the European species. [Fig. 9.]

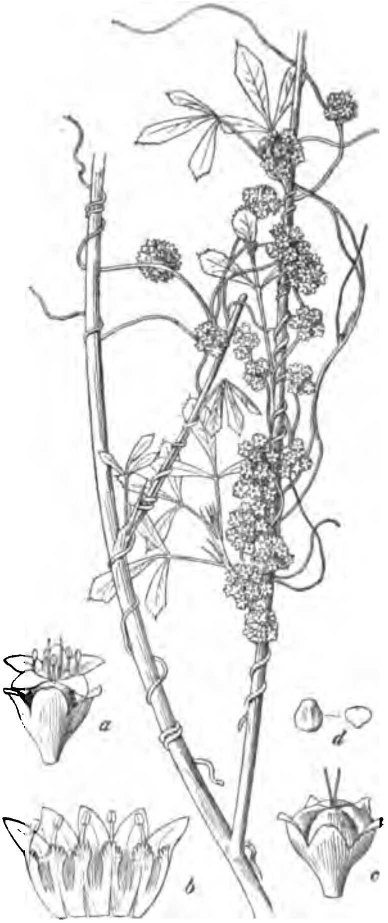


Fig. 9. Cuscuta Epithymum, Murr.
Plant natural size.

43. *CYNOGLOSSUM OFFICINALE, L. Hound's Tongue.

A European biennial established in waste places at Big Timber.

44. DRABA NEMOROSA, L.
Field draba.

A small annual of the Mustard family with yellow flowers and spreading pods, native of this region but inclined to multiply and grow rank in gardens and waste places.

45. DRACOCEPHALUM PARVIFLORUM, Nutt. Dragon-head.

An annual plant with dense square stems, opposite leaves and a terminal flowering spike inclined to frequent streets and waste places and occurs occasionally in cultivated ground. Doubtfully native here.

46. ECHINOSPERMUM DEFLEXUM AMERICANUM, Gray.

BEGGAR TICK.

A slender annual one or two feet high, widely branching above and with small blue flowers and slender racemes of reflexed burs. At Deer Lodge and Helena (Rydberg), Box Elder Creek, on the Ft. Peck Reservation, Arlee, Plains and abundant and troublesome in the streets, highways and waste places about Kalispell, where it is rapidly spreading into the country adjacent. It threatens to become a bad pest throughout the state. Certainly an introduced species in this region and doubtfully native in America.

47. ECHNOSPERMUM REDOWSKII, Lehm.

TICKSEED; BEGGAR TICKS.

A native annual resembling the preceding, but is smaller and has fewer erect fruit; common in loose soil about gopher hills, ant hills and prairie dog towns. A common weed in waste places throughout the Yellowstone region and in many places east of the Divide, but more rare westward. Occurs here as the varieties *occidentale*, Wats, and *cupulatum*, Gray, the latter much more rare.

48. ELLISIA NYCTELEA, L.

A small, diffusely branched, spreading annual with deeply lobed leaves and inconspicuous flowers. Not infrequent in low grain fields and waste places. Rarely abundant enough to be troublesome. Doubtfully native here.

49. EPILOBIUM ANGUSTIFOLIUM, L. IRONWEED; FIREWEED.

A tall, slender plant, about three feet high with a terminal raceme of large purple flowers, blooming about the first of August. Common in the foothills and mountains and the large perennial rootstock is often difficult to kill out in new ground.

50. EPILOBIUM PANICULATUM, Nutt. COTTON WEED.

A tall and very slender, smooth, widely branching annual with inconspicuous leaves and small red flowers, spreading eastward from the Pacific along the railways and principal lines of travel. Common along streets, highways and waste places in the western part of the state; the cottony seeds are distributed by the winds.

51. ERIGERON CANADENSIS, L.

RAGWEED; FIREWEED; HORSEWEED.

A slender, hairy annual with narrow leaves and a large terminal broom of greenish flowers and cottony fruit imported from the eastern United States. Becoming frequent in waste places, gardens and grain fields, and a serious pest in the Flathead valley. Size varies from a few inches to several feet; seed spread by the wind.

52. EUPHORBIA GLYPTOSPERMA, Engelm. CARPET WEED.

A small, much-branching annual, lying flat on the ground and forming circular carpets a foot or more in diameter. Apparently native but frequent by roadsides and in grain fields and waste places; rarely troublesome.

53. EUPHORBIA MARGINATA, Pursh. SNOW ON THE MOUNTAIN.

An annual, one to two feet high, with milky juice and upper leaves white margined. In waste places and along railway grades from Miles City to Glendive. Coming in from the eastward. Reputed poisonous.

54. FRANSERIA HOOKERIANA, Nutt.

An annual weed very much like the Ragweed (Ambrosia artimisiæfolia), but with fruit of conspicuous burs. Frequent in sandy soil along highways and in streets and waste places in many parts of the state east of the Divide. Possibly native, although it has all the habits of an introduced weed.

55. GAURA COCCINEA, Nutt. BUTTERFLY WEED.

A native perennial with long, deeply penetrating rootstock, frequent in new ground and occasionally found in grain fields and fallow land, mainly as the variety *glabra*, T. & G. Leaves narrow, flowers white or rose-colored, turning to scarlet in fading.

56. GAURA PARVIFLORA, Dougl.

A tall, hairy annual or biennial, two or three feet high, with small flowers and long, slender spikes of spindle-shaped fruit, occasionally troublesome in grain fields and waste places in the Missouri river region. Apparently introduced from eastward.

57. GERANIUM CAROLINIANUM, L. CRANE'S-BILL.

The typical form occasional in waste places; the form *G. Bicknellii*, Britt. not infrequent in waste places in many parts of the state.

58. *GERANIUM PUSILLUM, L.

Well established as a weed in fields and waste places about St. Ignatius, Flathead Reservation, and at Plains.

59. GLYCYRRHIZA LEPIDOTA, Pursh. WILD LIQUORICE; CUCKLEBUR.

A native perennial in low ground with pea-like leaves and bearing clusters of burs very like those of the true cucklebur (Xanthium). Its long, creeping, underground stem makes it difficult to eradicate from new land, and it is frequently abundant and troublesome in meadows and pastures. Persistent cultivation or digging seems to be the only remedy other than close pasturage.

60. GRINDELIA SQUARROSA, Dunal. ROSIN-WEED; WILD ARNICA.

A biennial doubtfully native in this region. About 18 inches high with a stiff stem and many heads of yellow-rayed flowers covered with a gummy secretion. Common in the plains and valleys east of the mountains and spreading westward. More frequent along roadsides and waste places and troublesome in meadows and pastures, where it is difficult to eradicate after having once obtained a foothold. Stock rarely will eat it in any situation. Just being introduced in the Flathead and Bitter Root valleys by roadsides and should be exterminated before it becomes established. Old settlers say the plant has come into much of this region since the advent of civilization and there seems now to be a steady advance westward, although its distribution is effected mainly by the conveyance of its seeds in the mud on the feet of animals and the wheels of vehicles and in hay.

61. HELIANTHUS ANNUUS, L. SUNFLOWER.

An annual weed, three or four feet high, with large notched leaves and large yellow-rayed heads three inches in diameter, common everywhere east of the Divide and one of the worst weeds in grain fields and cultivated ground. Occasional along the railways in the western part of the state, but not troublesome there except in the Bitter Root valley. It is confined to one or two small areas in the Flathead valley and shows small disposition to spread in the absence of irrigation, but if the farmers are wise they will stamp out this pest at once, lest it become as troublesome there as it has in other parts of the state. Seeds seem to be distributed largely by irrigation and in the mud adhering to to feet and to the wheels of vehicles. Its seeds seem to lie in the ground many years before losing their vitality and it can best be combatted by sowing the infected fields in some annual grain suitable for forage and pasturing with sheep for several years.

62. HELIANTHUS NUTTALLII, T. &. G.

A native perennial sunflower, more slender and with narrower leaves than the last; roots tuberous and with frequent underground stems. Usually in small patches, and can best be destroyed by pulling or digging after irrigation. Often troublesome in grain fields and low ground in the western part of the state.

63. HELIANTHUS PETIOLARIS, Nutt.

An annual very like and commonly confused with *H. annuus* above and frequent in dry, sandy situations in the Milk River and Yellowstone valleys. It has smaller heads than the common sunflower (H. annuus) and narrower, entire leaves.

64. **HORDEUM JUBATUM, L.** FOXTAIL; SQUIRREL-TAIL GRASS; SLOUGH-GRASS.

An annual or biennial grass with a large, bushy spike of fruit, whose long

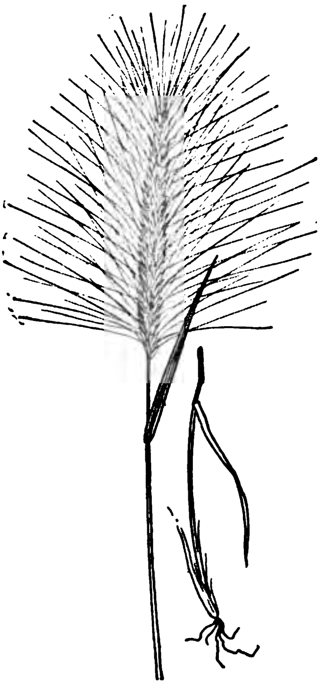


Fig. 10. Hordeum jubatum, L. Natural size.

awns when ripe pierce the lips and tongue of stock and cause extensive ulceration. A common weed in pastures and waste places seemingly introduced from the east; doubtfully native. It makes little headway against the native vegetation, but tends to become established in low ground wherever that vegetation has been disturbed or kept down by close pasturage. Said to make fair hay, if cut before heading out or after the head breaks away in August. It may be killed out in most situations by plowing it under in June or by seeding the fields in grain for a few seasons. It is also doubtful if it can make much headway against a good stand of clover, timothy or alfalfa. [Fig. 10.]

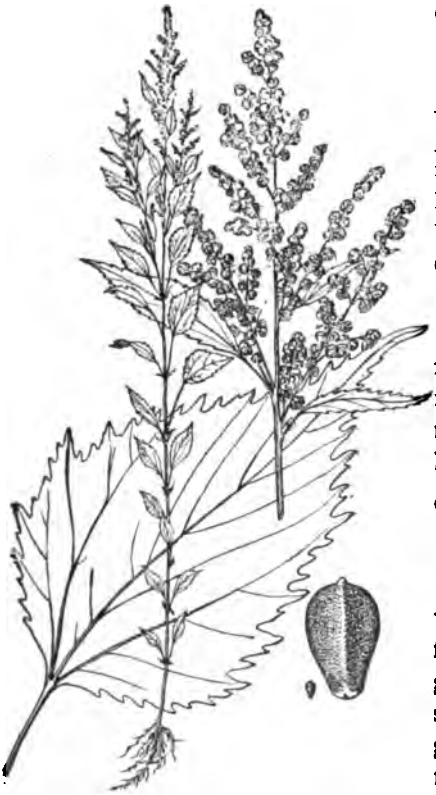


Fig. 11. Iva xanthiifolia, Nutt. Plant 1-12 natural size; leaf and fruit ½.

65. *HYOSCYAMUS NIGER, L.

BLACK HENBANE.

A coarse European annual or biennial established in waste places at Billings (E. V. Wilcox), Big Timber, and rarely about Bozeman. Poisonous.

66. *HYSSOPUS OFFICINALIS, L. HYSSOP.

A sage-like perennial with narrow leaves and clustered blue flowers, occasionally escaped from gardens. Roadsides in Flathead valley, rare.

67. IVA AXILLARIS, Pursh.

BAZZLE-WEED; POVERTY-WEED.

A native perennial a foot or two high growing in clumps or forming extensive patches in low ground, particularly in alkaline soil. Its long creeping underground stems make it most difficult to eradicate. Probably best combatted by seeding down in meadow.

68. IVA XANTHIIFOLIA, Nutt. CARELESS-WEED; HORSE-WEED; GIANT RAG-WEED.

A tall, coarse native annual, three to six feet high, with large, heart-shaped toothed leaves opposite on the smooth stem. This is one of the worst weeds in the Gallatin valley, by roadsides, in waste places and cultivated ground, and is not infrequent in low ground east of the Divide, but apparently rare west of it. Its small, black seeds seem to be distributed wholly by water and the mud of passage and so it is not apt to be very troublesome except in irrigated districts. [Fig. 11.]

69. KRINITZKIA CRASSISEPALA, Gray.

Frequent in loose soil with *Echinospermum Redowskii* in the Yellowstone region; apparently not west of the Divide.

70. LACTUCA PULCHELLA, DC. MILKWEED; WILD LETTUCE.

A native perennial of the lettuce family common in all situations throughout the eastern part of the the state; leaves smooth, often with long, slender teeth; flowers blue, closing in the afternoon. In low ground the long underground rootstocks makes its extirpation difficult. The black seeds with a tuft of hairs at apex are distributed by the wind.

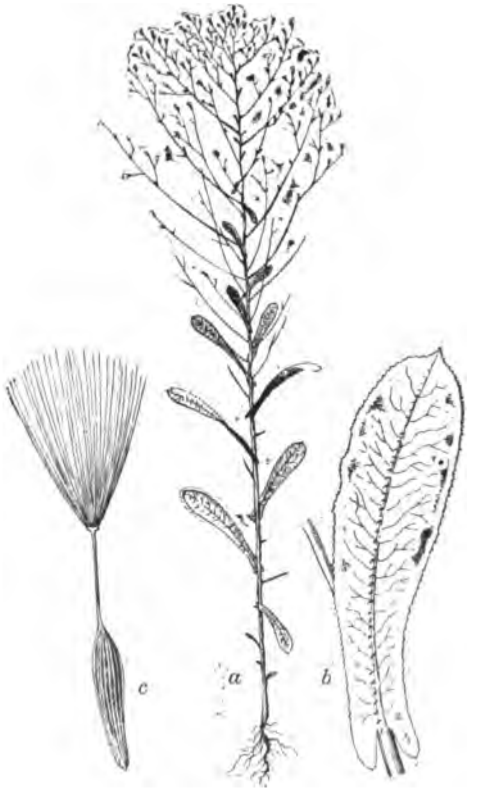


Fig. 12. Lactuca Scariola, L. a, 1-9; b, natural size; c, enlarged.

71. LACTUCA SCARIOLA, L. PRICKLY LETTUCE; CHINESE LETTUCE.

A European biennial resembling the preceding species, but the flowers are light yellow and the leaves are prickly-fringed and not lobed, and have a curious habit of twisting to the vertical with a tendency toward a north and south direction, like a "compass plant." A most pernicious weed introduced along the railroads in nearly every part of the state but most frequent from Missoula west and south and worst about Plains and Hamilton. It should be destroyed in the localities in which it is established and not permitted to spread and increase the number of our already too numerous European pests. [Fig. 12.]

72. *LAMIUM AMPLEXICAULE, L. DEAD NETTLE.

A European annual introduced with garden seed from the east and well established near Ennis. A prostrate or creeping plant resembling the Ground Ivy, having small, rounded, opposite leaves with purple flowers in the axils. Unlikely to become troublesome except in irrigated gardens.

73. *LEONURUS CARDIACA, L. MOTHERWORT.

A European perennial well established in waste places about Missoula, and one or two other points in the state.

74. LEPACHYS COLUMNARIS, T. & G. CONE-FLOWER.

A native perennial of the plains region, one or two feet high, with rough divided leaves and long-stalked flowers with a dark columnar disk and drooping yellow rays. Spreading westward and often troblesome in meadows, pastures and waste places, particularly in dry sandy soil.

75. LEPIDIUM APETALUM. Willd. BIRD-SEED; PEPPER-GRASS.

A small acrid-tasting annual a few inches to a foot high, frequent in dooryards, waste places and cultivated ground. Doubtfully native, although well distributed throughout the plains region. Seeds become mucilaginous when wet and thus facilitate their distribution by animals.

76. LUPINUS PUSILLUS, Pursh. DWARF LUPINE.

A small bulbous-rooted perennial, less than a foot high, with a long-stalked seven-foliate leaf and spike-like racemes of blue flowers, frequent in sandy soil in the Yellowstone and Milk River regions, and often troublesome in grain fields and cultivated ground. Native.

77. LUPINUS SERICEUS, Pursh. LUPINE; PRAIRIE BEANS.

A native perennial common in dry ground throughout the state. Like the last but larger, one to three feet high. Persistent with long, creeping rootstocks in new ground and difficult to exterminate except by digging or long cultivation.

78. LYGODESMIA JUNCEA, Don. WILD ASPARAGUS; SKELETON-WEED.

A slender-stemmed branching native plant, one or two feet high, apparently leafless, with purplish flowers and long penetrating rootstocks, often troublesome in cultivated ground in the region east of the Divide. [Fig. 13.]

79. *MADIA FILIPES, Gray. SMALL TARWEED.

A small, slender Pacific Coast tarweed, which has reached our borders along the railways in the western part of the state. Well established in waste places about Troy, Libby and Thompson Falls. Annual.

80. MADIA GLOMERATA, Hook. TARWEED.

Another Pacific Coast annual similar to the last but much larger, about two feet high, with sticky, ill-smelling herbage and terminal clusters of inconspicuous flowers. In waste places, pastures and along roadsides eastward as far as Bozeman and appears to be rapidly spreading eastward in the state.

81. *MALVA PARVIFLORA, L. RUNNING MALLOW.

A small annual European mallow, noted in waste places about Conrad on the G. F. & Can. Ry. (R. S. Williams), Thompson Falls and Plains.

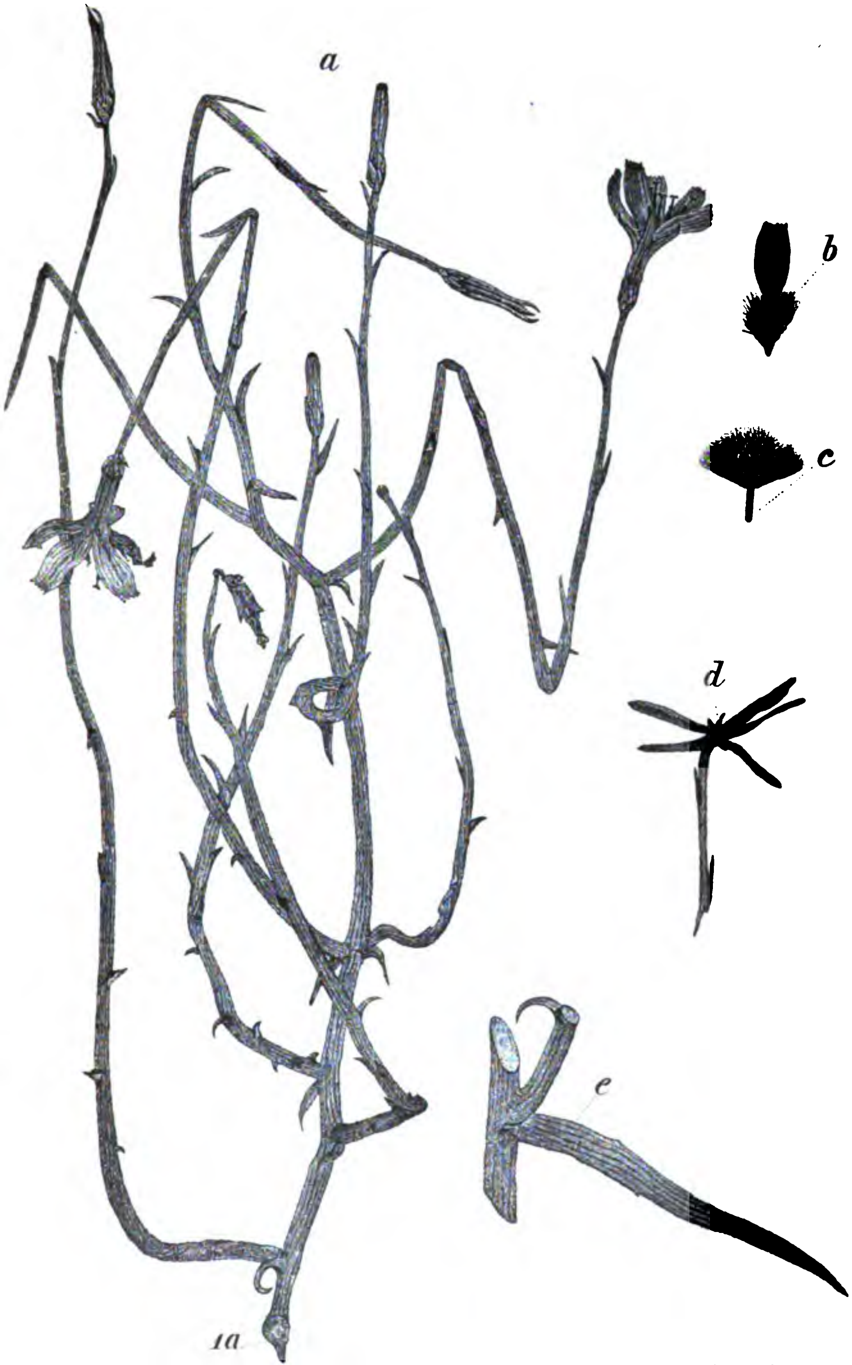


Fig. 13. Lygodesmia juncea, Don. Plant natural size; b-e enlarged.

82. MALVASTRUM COCCINEUM, Gray. Wild Hollyhock.

A small native perennial about six inches high, with divided leaves, and brick-red flowers, not infrequent in waste places eastward, and often persistent in new ground; hardly large enough or sufficiently abundant to be troublesome.

83. **MARRUBIUM VULGARE, L.** Horehound.

A white-woolly European perennial, one or two feet high, with opposite, roundish leaves, and the flowers and fruit clustered in the axils of the upper leaves. Seeds disseminated by the burlike calyx. This has been found to be one of the worst weeds in Idaho and Utah, and is becoming very troublesome in streets, roadsides and waste places along the railroad from Missoula westward, but rare elsewhere in the state. Coming in from the west.

84. MATRICARIA DISCOIDEA, DC. Rayless Dogfennel.

A Pacific Coast annual resembling the dog-fennel (Anthemis Cotula) and similarly ill-scented, but without the white rays and much smaller. Frequent in streets and waste places and along highways throughout the western part of the state. Introduced from the west and rapidly spreading eastward.

85. **MELILOTUS ALBA,** Lam. Sweet Clover; White Melilot; Honey Clover.

An annual or biennial, three to six feet high, frequent in many places along irrigation ditches and in waste places, particularly in the Yellowstone valley, where it has been found most troublesome. Much resembles alfalfa, but is taller and more slender and has white flowers, while its value as a forage plant is questionable. It appears to grow best in alkali ground. Introduced from Europe. Seeds appear to be scattered by water and in hay.

86. *MELILOTUS OFFICINALIS, Willd. Yellow Melilot.

Like the preceding, but with yellow flowers. In waste places at Helena (F. D. Kelsey), White Sulphur Springs (R. N. Sutherlin), and Miles City. Infrequent.

87. **MONOLEPIS CHENOPODIOIDES,** Moq. Poverty Weed.

A native annual prostrate or ascending with green inconspicuous flowers and abundant fruit; fruiting throughout the season.

much resembling *Chenopodium glaucum*. One of our most troublesome weeds in yards, gardens and waste places.

88. *NASTURTIUM ARMORACIA, Fries. HORSE RADISH.

In waste places an occasional escape from cultivation.

89. *NEPETA CATARIA, L. CATNIP.

A well-known European perennial becoming established in waste places at Helena (F. D. Kelsey), Columbia Falls, Holt, Thompson Falls, Plains and a few other places in the state.

90. ŒNOTHERA BIENNIS, L. YELLOW EVENING PRIMROSE.

A slender biennial three or four feet high with yellow flowers and spindle-shaped fruit about an inch long, introduced along the railroads and highways in most parts of the state and frequently so common as almost to appear native in low ground (O. depressa, Greene and Onagra strigosa, Rydberg).

91. PANICUM CAPILLARE, L. TUMBLE-GRASS.

A hairy annual grass with a widely spreading panicle of fruit easily detached when ripe; occurs occasionally in fields and waste places particularly in the Plains region. Here doubtfully native.

92. *PANICUM CRUS-GALLI, L. BARNYARD GRASS.

An introduced annual rare in fields, yards and waste places; here usually prostrate and spread by irrigation. At Ulm (R. S. Williams), Bozeman, Malta and Chinook.

93. *PANICUM SANGUINALE, L. CRAB-GRASS.

Occasionally imported from the east in grass seed, but shows little or no disposition to spread. Noted at Great Falls and Bozeman.

94. PASTINACA SATIVA, L. PARSNIP.

Often escapes from cultivation and is found occasionally in old fields, waste places and along irrigation ditches.

95. PLANTAGO ASIATICA, L. NATIVE PLANTAIN.

The common plantain in ditches and low ground by roadsides and in waste places, apparently native.

96. **PLANTAGO MAJOR, L.** PLANTAIN.

A European perennial abundantly introduced in lawns, pastures and waste places about Deer Lodge, Columbia Falls, Bozeman and most of the larger towns and cities of the state. Like the dandelion, it is difficult to eradicate from lawns except by digging. It should not be allowed to secure a foothold in a community. This species is very difficult to distinguish from the one above, except that it is smaller and more smooth, has shorter and more abrupt spikes of fruit, central dehiscence of the capsule and a more pestiferous habit of frequenting lawns, yards and waste places.

97. PLANTAGO PATAGONICA GNAPHALIOIDES, Gray. RIBGRASS.

A native annual of the plains region, frequent in dry ground and with a decided tendency to crowd out the grasses in pasture land, when close cropped. The variety *aristata*, Gray, occurs with the other form but is much less frequent. This has been quoted as a weed from this state, but has value as a forage plant. The seeds of all these plantains becomes mucilaginous when wet, adhere to everything they touch and so are easily transported in the mud of passage.

98. *POA ANNUA, L.

A small annual grass from Europe, a few inches high in streets and waste places at St. Ignatius, Columbia Falls and a few other places in the state, but of no special importance.

99. **POLYGONUM AVICULARE, L.** KNOTGRASS; YARDGRASS; GOOSEGRASS.

An introduced annual forming carpet-like patches in yards, waste places, streets and along highways, often trailing for several feet. It has a smooth, wiry stem, small leaves and inconspicuous flowers. Common in beaten ground throughout the state; mainly in the coarser, blunt-leaved form (P. littorale, Link.), though both occur.

100. POLYGONUM ERECTUM, L.

An introduced weed very similar to the last, but is usually erect and with broad oval leaves. Noted at Bozeman, Malta, the Ft. Peck Reservation near Calais, Forsyth and Glendive.

101. POLYGONUM CONVOLVULUS, L. WILD BUCKWHEAT.

A climbing or trailing vine with heart-shaped leaves and buckwheat-like fruit common in yards, waste places and cultivated ground in the settled parts of the state. An annual introduced from Europe and the East and now become one of our worst weeds.

102. POLYGONUM LAPATHIFOLIUM, L. SMARTWEED.

A smooth annual with swollen joints and small terminal spikes of purplish or white flowers, one to three feet high. Introduced about waste places, gardens and in cultivated ground; not infrequent.

103. POLYGONUM PERSICARIA, L. SMARTWEED.

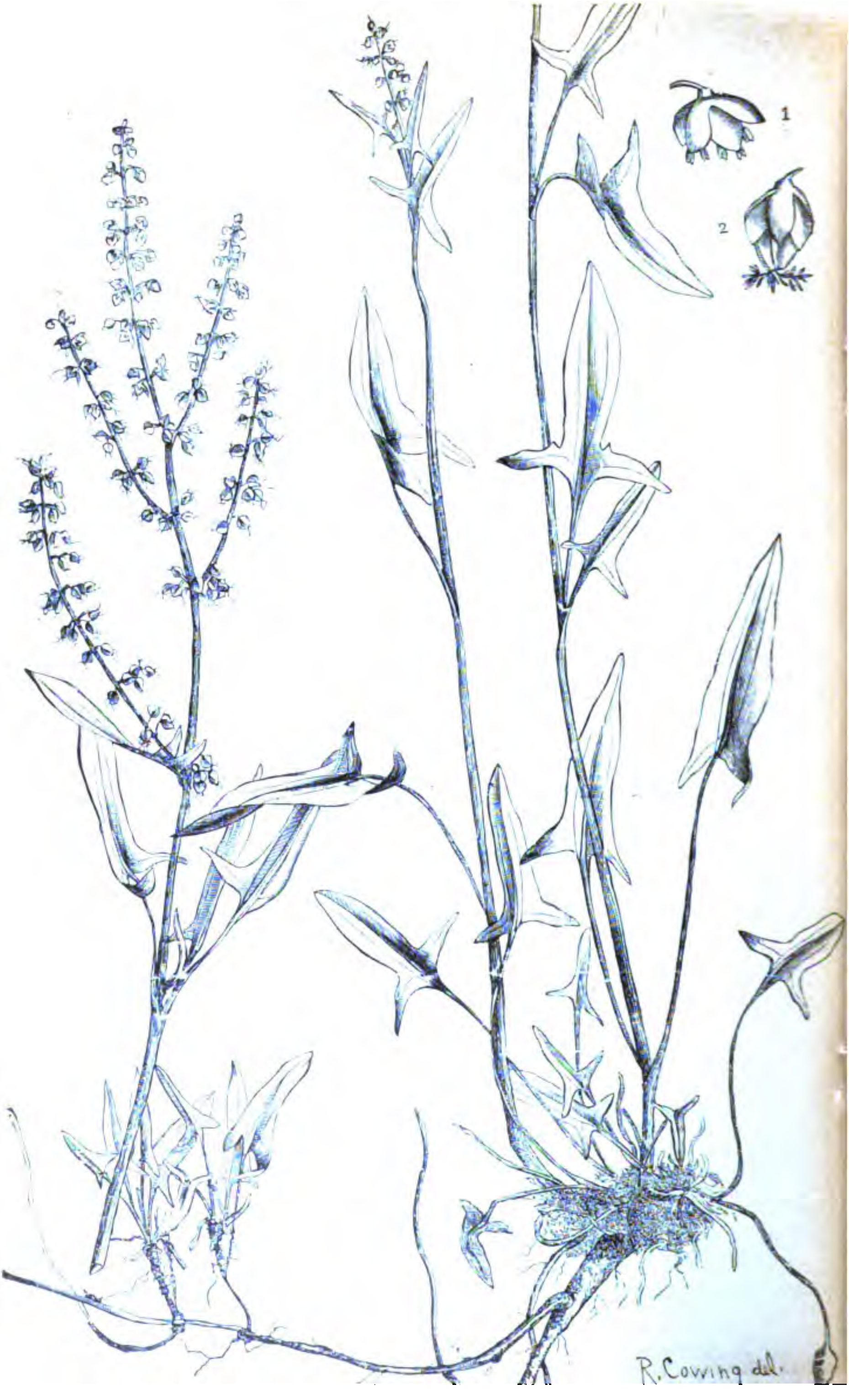
A not infrequent introduction in wet places, but hardly troublesome. Like the last, but lower and with thicker and more brightly colored spikes.

104. *PORTULACA OLERACEA, L. PURSELEY.

A brittle, fleshy annual with small yellow flowers, forming broad mats. This eastern pest has appeared in gardens occasionally, introduced with garden seed, and grows vigorously in irrigated ground. Not likely to be more than locally troublesome, but should be exterminated in every case lest it become established and difficult to control. Noted in gardens and in waste places at Bozeman, Ennis, Craig, Forsyth and Glendive.

105. RUMEX ACETOSELLA, L. SHEEP SORREL.

A perennial one or two feet high with small leaves, having ear-like lobes on each side near the base and a strong acid taste, and with slender terminal naked sprays of small green flowers or fruit. Forms patches in meadows, pastures and waste land, spreading by means of long underground rootstocks, and, like the Canada thistle, very difficult to exterminate after it gets established. This is going to be one of the worst weeds in the state, as it is well adapted to our climatic conditions and has a footing in many places over the state, particularly westward. It has fairly taken


1
2
R. Cowing del.

some grain-fields in the Gallatin Valley and is bad in several parts of the Flathead Valley, while it is common along the railroad from Missoula westward, apparently coming in from the Pacific coast. This should be included among the outlawed weeds of the state. [Fig. 14.]

106. RUMEX CRISPUS, L. CURLY-LEAVED DOCK; BURDOCK.

A large perennial dock established in streets and waste places about most of the larger towns of the state but not as yet common or very troublesome. The large thick roots must be removed by digging.

107. RUMEX SALICIFOLIUS, Weinm. WILLOW-LEAVED DOCK.

A coarse weed like the last but with narrower leaves; frequent along roadsides, in waste places and pastures. Apparently introduced from the west; possibly indigenous.

108. SALSOLA KALI TRAGUS, Moq. RUSSIAN THISTLE.

An introduced annual with little or no resemblance to a thistle. It has awl-shaped leaves, a green stem, striped with red, and prickly fruit-bracts, becoming hard and spiny in age; flowers and fruit small and inconspicuous. It often forms a large globular mass a yard or more in diameter, which finally becomes detached and is rolled about by the wind like the tumble-weed. It favors sandy or alkali soil for growth and frequents railway grades, streets and waste places about towns and cities; seems to make no headway against the native vegetation in the open fields and plains. This is one of the three outlawed weeds of Montana and doubtless well deserves to be included in the list, but, as far as my observation goes, it has not yet become a pest here in cultivated ground, although well scattered over the state, and hardly deserves the bad reputation given it. In its younger growth it makes fair forage and is occasionally cut for hay, so that it may yet prove a valuable forage plant adapted to alkali situations, where little else will grow. Well scattered in the Milk River and Yellowstone

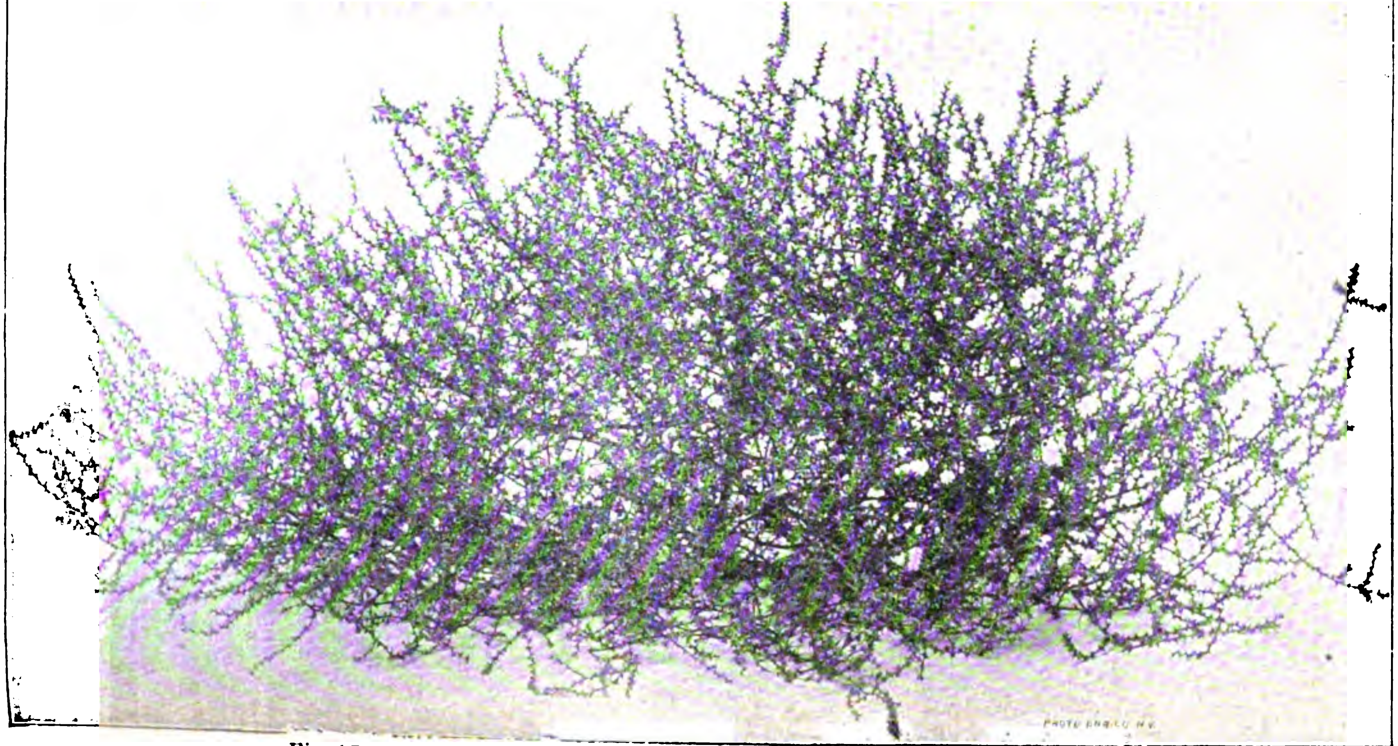


Fig. 15., a. Salsola Kali Tragus, Moq. General habit of growth. 1-12 nat. size.

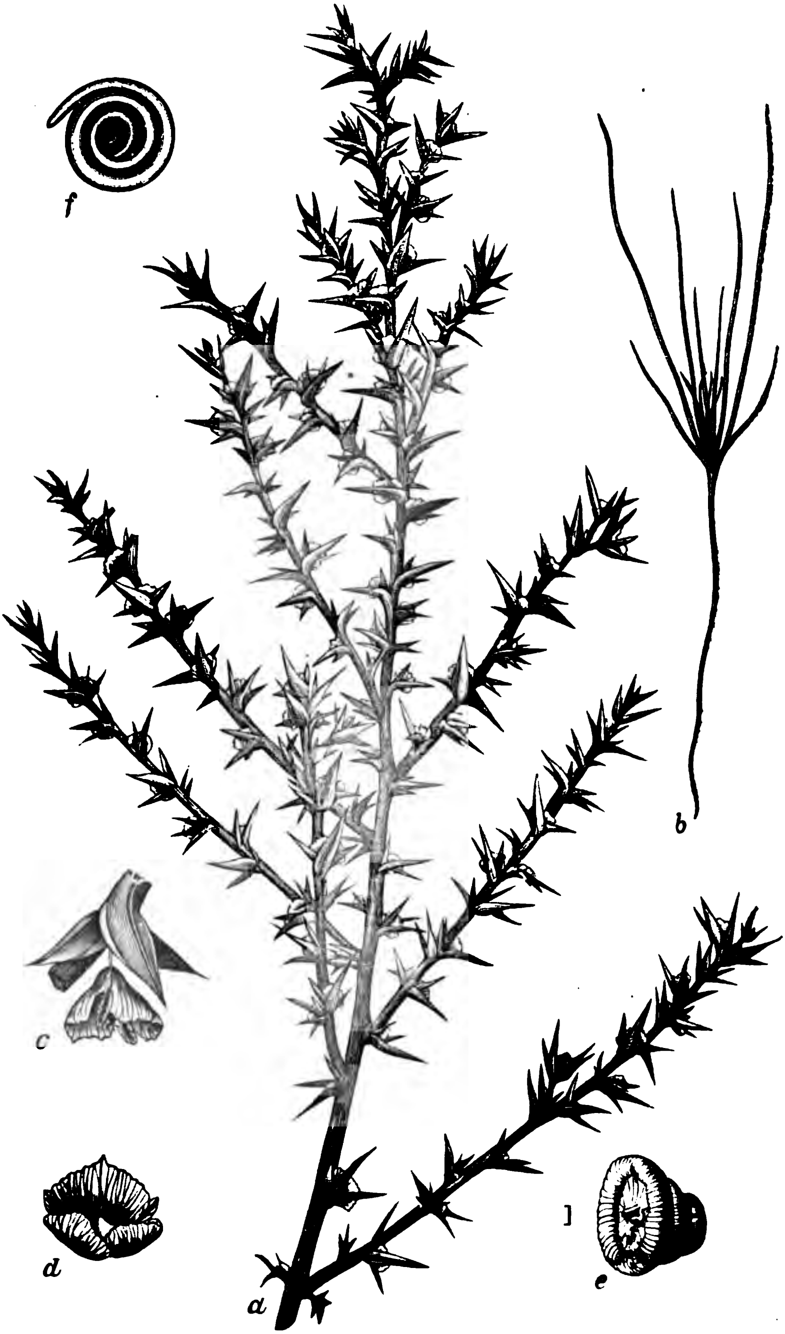


Fig. 15 b. Salsola Kali Tragus, Moq. Seedling and branch natural size; flower and fruit enlarged.

regions; at Missoula and Helena and reported from Manhattan, Livingston, Billings, Cinnabar, Great Falls and at points along the railway in Silver Bow and Beaverhead counties. It is easily uprooted with a hoe and should be piled into heaps and burned when dry, as the smallest plants bear fruit and will serve to restock the soil, if simply dug up and left. Mowing the plants, as is frequently done, is of little aid toward their extermination, as the stubs remaining will bear enough fruit to replant the soil for the ensuing season. It is better adapted to the conditions existing in the Milk River and Yellowstone Valleys than elsewhere in the state and may there prove a serious menace to the agricultural interests, but should be exterminated wherever found, as the law requires. Seeds distributed principally by the railways, irrigation ditches and mud of passage. [Fig. 15 a and b.]

109. SAPONARIA VACCARIA, L. COCKLE; COW COCKLE.

A smooth European annual, one or two feet high; with opposite, clasping leaves and conspicuous pink flowers terminating the level-topped spread of branches. A common and pernicious weed in grain fields in the eastern part of the state, but rare westward. It should not be allowed to secure a footing in regions not yet infected and may be hand-pulled where the plants are few or its distribution limited. Usually introduced and spread in the grain seed and, apparently, by irrigation. [Fig. 16.]

110. *SENECIO VULGARIS, L. GROUNDSEL.

An annual, about a foot high, with divided leaves and inconspicuous heads of flowers, somewhat resembling a thistle. In waste places at Columbia Falls and Big Timber. From Europe.

111. *SILENE NOCTIFLORA, L. CATCHFLY.

An introduced annual noted in fields and waste places about Bozeman. An herb one or two feet high, with sticky hairs, opposite leaves and white flowers. Unlikely to become troublesome in this state.

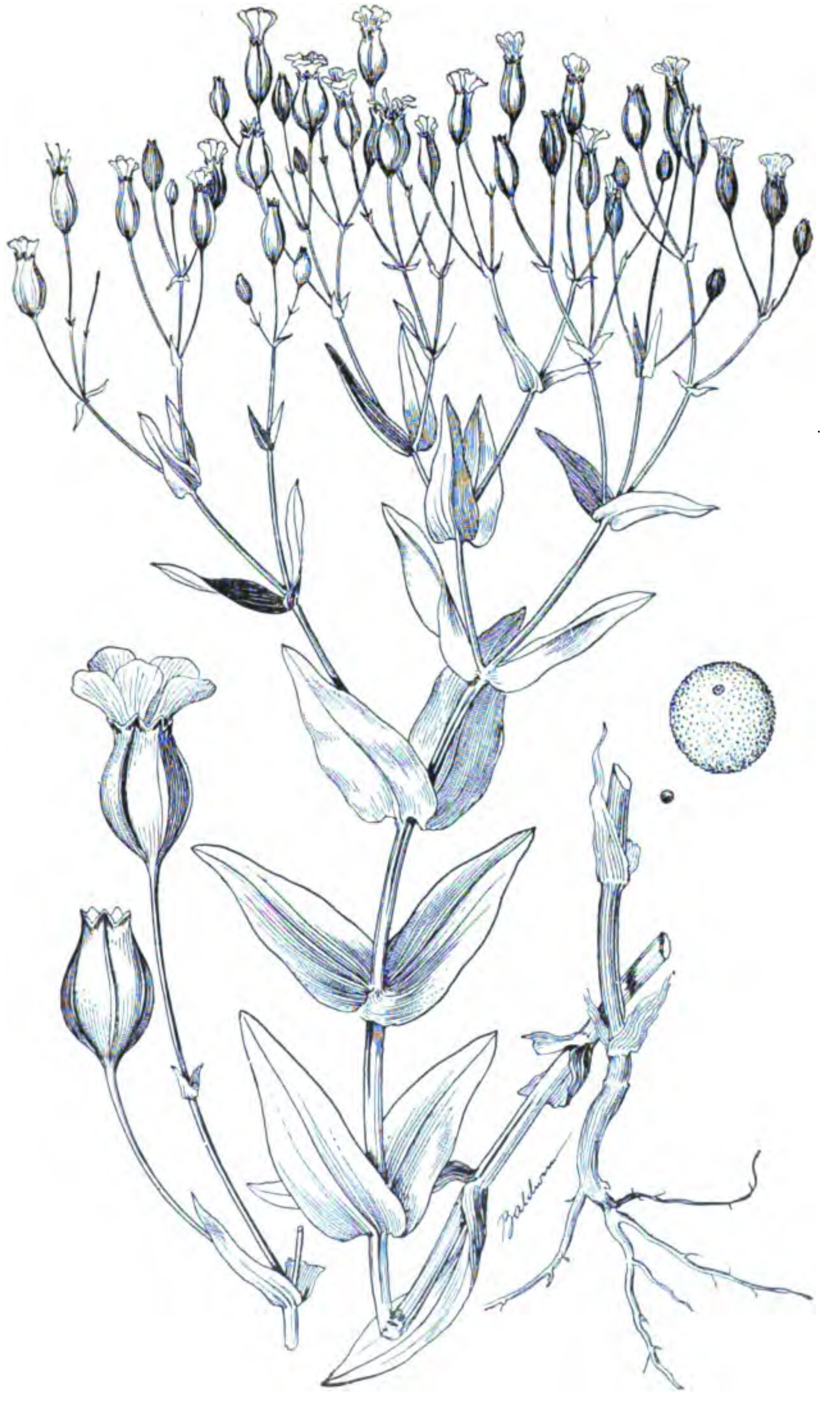


Fig. 16. Saponaria Vaccaria, L. Plant about one-half natural size.

112. SISYMBRIUM ALTISSIMUM, L. TUMBLING MUSTARD.

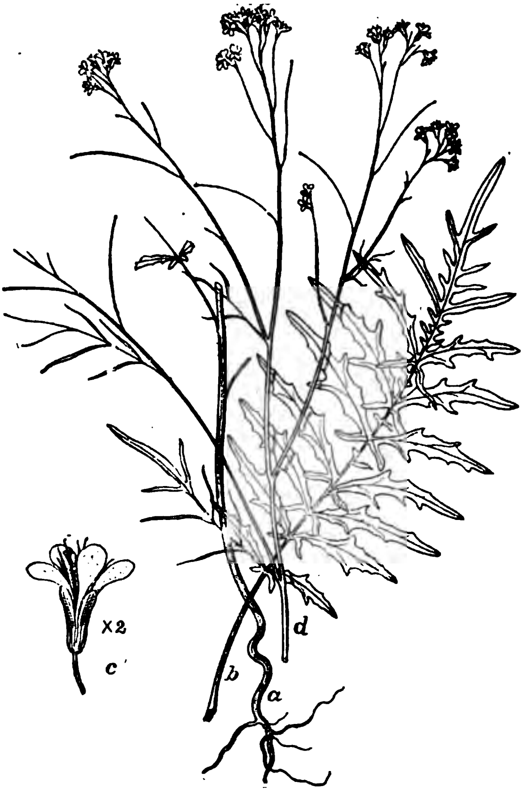


Fig. 17a. Sisymbrium altissimum, L. a and d ⅓; b and c natural size.

A European annual of the mustard family, two or three feet high, with upper leaves narrow or finely divided and the lower broader-lobed, and having a widely branching, level-topped spread of yellowish flowers and slender fruit pods two or three inches long. This has been found to be a most pernicious weed in Canada north of this state and is extending southward. Specimens have been collected at Great Falls, Helena, Central Park and Belgrade, and it is fairly taking the grain fields in some parts of the Bitter Root and Flathead valleys. It should not be allowed to secure a footing in any agricultural section, as its enormous fertility, tumbling habit, and special adaptation to our climate will probably make it far more dangerous to the farmer than any of the weeds already outlawed in the state. [Figs. 17 a and b.]

113. SISYMBRIUM INCISUM, Engelm. TANSY MUSTARD.

A slender annual of the mustard family, one to three feet high, having small, yellow flowers, short spreading pods and finely divided leaves. Common along roadsides, in grain fields and waste places. Has the appearance of a native in some parts of

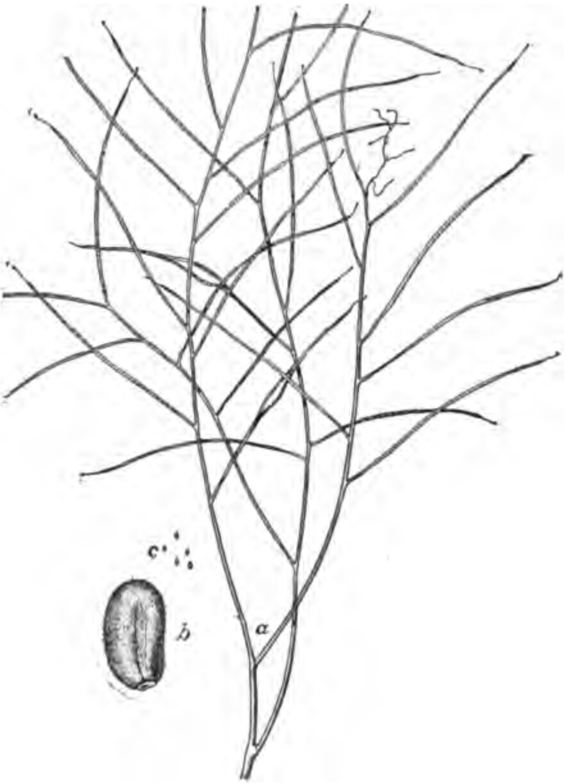


Fig. 17b. Sisymbrium altissimum, L. Fruit ¼ natural size; b enlarged.

the state east of the Divide, but is local in its distribution. Seeds scattered by water and in mud.

114. *SISYMBRIUM OFFICINALE, Scop. Hedge Mustard.

Another introduced annual, occasional in waste places, but not likely to become troublesome. At St. Ignatius, Troy, Helena, Bozeman and Missoula.

115. *SOLANUM NIGRUM, L. Deadly Nightshade.

An introduced annual in waste places at Columbia Falls (R. S. Williams), and Selish (V. K. Chesnut).

116. **SOLANUM ROSTRATUM**, Dunal. BUFFALO BUR.

A prostrate annual, with yellow flowers and a bur-like fruit, thickly covered with long, yellow spines. Coming into the state from the east along the railways and becoming troublesome in yards, waste places and cultivated ground. At various points along the Yellowstone, Missoula, Box Elder Creek, Glasgow and Culbertson. It should be killed out in all localities before it becomes a pest. It spreads slowly, but holds well where established.

117. **SOLANIUM TRIFLORUM**, Nutt. WILD TOMATO; STINKWEED.

A prostrate spreading annual with lobed leaves, small white or pale blue flowers and numerous green, many seeded berries. Frequent in gardens, waste places and cultivated ground throughout much of the region east of the Divide. The host of the Colorado potato beetle. Doubtfully native. [Fig. 18].

118. **SONCHUS ASPER**, Vill. SOW THISTLE; YELLOW THISTLE.

A thistle-like annual with spiny clasping leaves and yellow flowers; two or three feet tall. Introduced from Europe by way of the eastern states and now frequent and often troublesome in gardens and cultivated ground, particularly about Bozeman and Kalispell. Seeds feathery and scattered by the wind.

119. *SONCHUS OLERACEUS, L.

Very similar to the last and commonly not distinguished from it. It is more slender, less prickly and has cross-ribbed seeds. It occurs with the other species, but is far less frequent.

120. *SPERGULA ARVENSIS, L. FIELD SPURRY.

An annual introduced from the Old World with slender, branching stems and numerous clusters of thread-like leaves. In grain fields at Bozeman but not elsewhere noted.

121. *STELLARIA MEDIA, Smith. CHICKWEED.

A small, spreading annual naturalized from Europe, in yards and waste places; occasional about Bozeman and other towns of the state.

122. *SUCKLEYA PETIOLARIS, Gray.

A prostrate annual, very much resembling the pigweed-purselv (Amaranthus blitoides, Wats.) but with larger and more orbicular

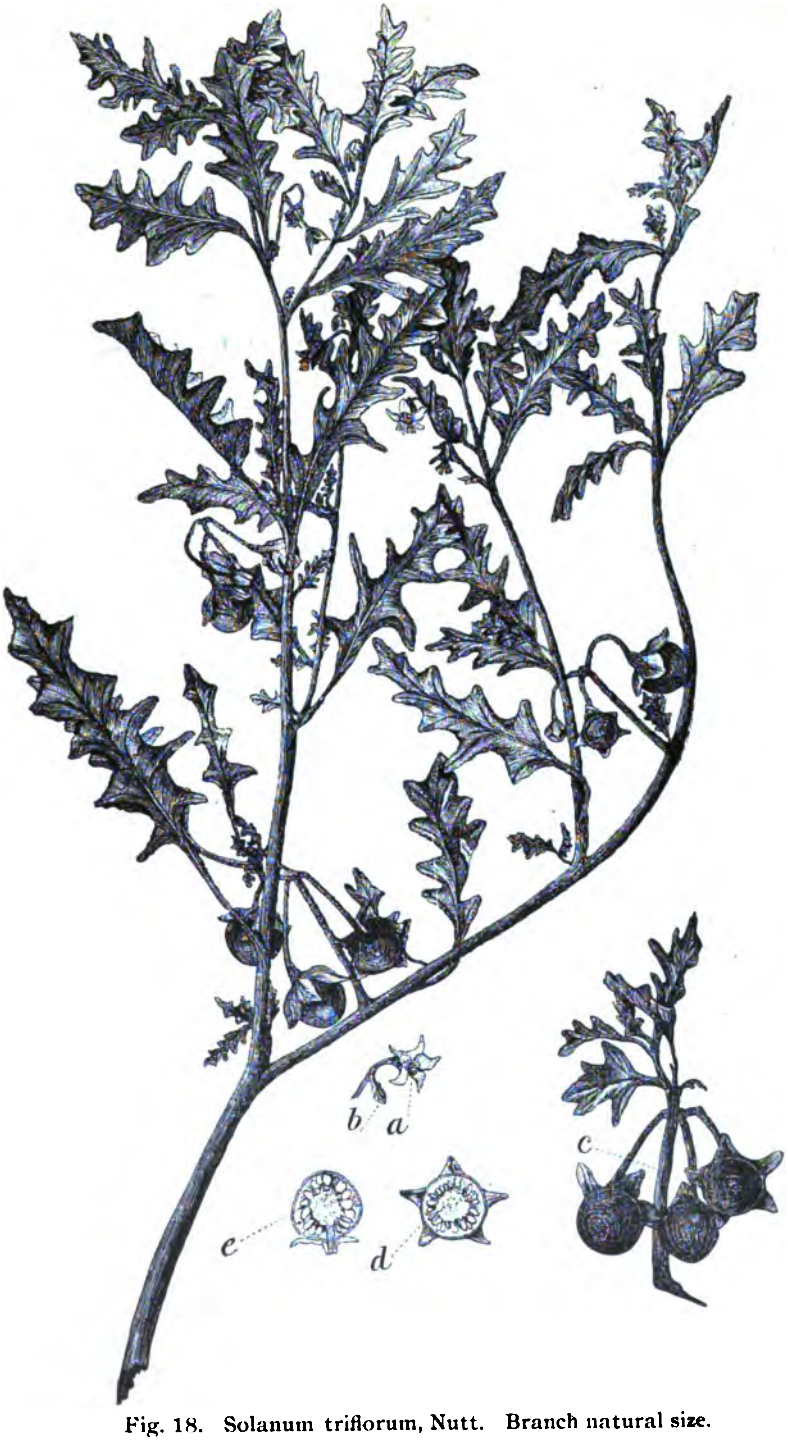


Fig. 18. Solanum triflorum, Nutt. Branch natural size.

leaves. It has as yet been noted in this state only in the Milk River region and, as far as my observation goes, only in a single locality in the town of Glasgow. Its abundance and decided weed habit may hereafter make it a pest in that region. Although the type locality, it is doubtless introduced here from the southern plains.

123. *SYMPHYTUM OFFICINALE, L. COMFREY.

A large coarse European perennial sparingly introduced in waste places about Bozeman.

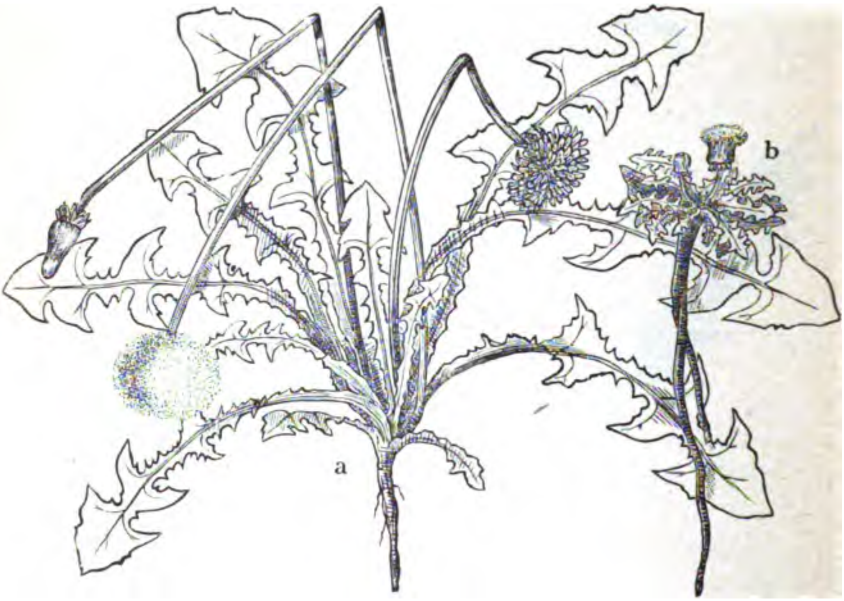


Fig. 19, Taraxacum officinale, Weber. Plant about ¼ natural size.

124. TARAXACUM OFFICINALE, Weber. DANDELION.

A perennial of European origin, with a long, deeply penetrating root which makes it difficult to eradicate. It has a cluster of lobed ground leaves from which arise the slender flower stalks with yellow flowers and round balls of plumose fruit, which are carried long distances by the wind. One of the worst weeds in the state in lawns, waste places and pastures about the larger towns, and can be exterminated only by cultivation or by digging; the latter is most effective when the roots are cut off just below the crown of leaves during the flowering season. Apparently well distributed in the state about towns. [Fig. 19.]

125. *THLASPI ARVENSE, L. PENNYCRESS.

An introduced annual of the Mustard family much resembling the birdseed (Lepidium apetalum) but having larger pods. Occasional in grain fields and waste places.

126. *TRAGOPOGON PORRIFOLIUS, L. SALSIFY; OYSTER-PLANT.

In gardens and waste places; not infrequently escaped from cultivation.

127. *URTICA DIOICA, L.

A perennial nettle about barnyards and in waste places in the Koutenai region. Infrequent. Apparently here, coming in from the west.

128. URTICA GRACILIS, Ait.

STINGING NETTLE.

A tall slender unbranched perennial with green fruit clusters in the axils of the upper leaves, and with stinging hairs. Not infrequent in streets and waste places and along highways in the region east of the Divide, but sparsely introduced westward. Usually regarded as native, but in this state its habit is wholly that of an introduced species and occurs only where its seeds may have been transported in hay, water or mud from points of settlement. [Fig. 20.]

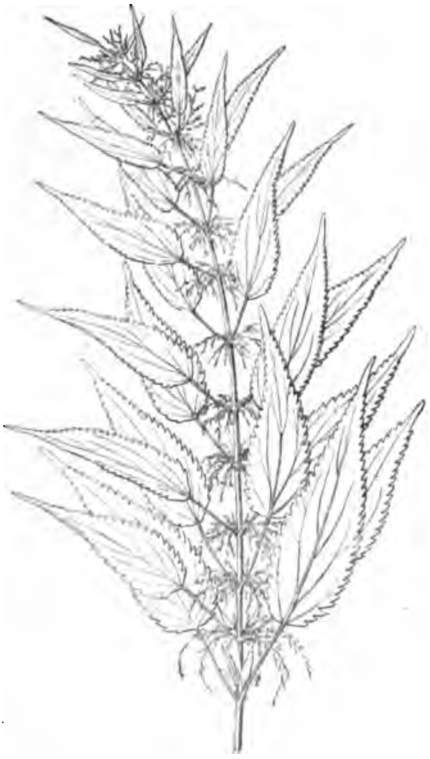


Fig. 20. Urtica gracilis, Ait. Branch ¼ natural size.

129. VERBASCUM THAPSUS, L. MULLEIN.

A thick, woolly-leaved biennial with a tall (two to six feet) unbranched stem and a terminal spike of yellow flowers. An introduced plant well established in many places about the state in fields and waste places and by roadsides. Most troublesome from Missoula south and west along the railroads. Common in the Flathead valley near Columbia Falls, along the Missouri below Craig and occasional in the Gallatin valley near Bozeman. Seems well adapted to our climatic conditions and is liable to become a serious pest.

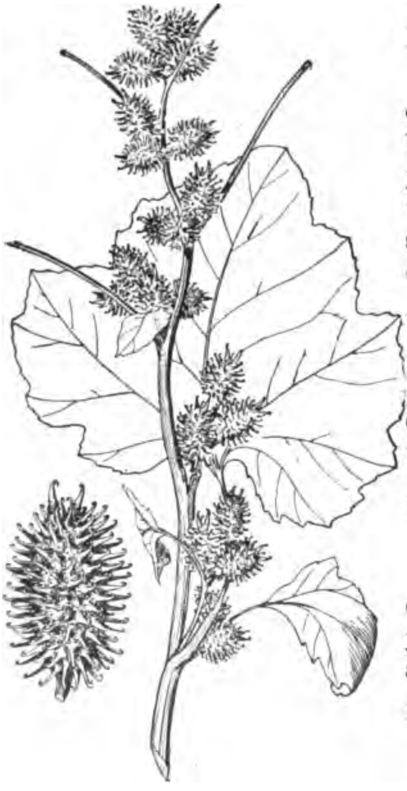


Fig. 21. Xanthium Canadense, Mill, Branch ⅓; bur natural size.

130. VERBENA BRACTEOSA, Michx. TRAILING VERVAIN; VERVAIN.

A perennial, native in the region east of the mountains. It forms broad mats along roadsides, in yards and waste places. A prostrate and bristly hairy plant with small blue flowers along the ends of the branches.

131. VERONICA PEREGRINA, L.

A small annual not infrequent here as a weed in grain fields and cultivated ground, but hardly troublesome.

132. *VERONICA BYZANTINA, B. S. P.

A small weed occasionally introduced in garden seed, but has not yet become well established. Noted at Bozeman.

133. XANTHIUM CANADENSE, Mill. COCKLEBUR.

A coarse annual with heart-shaped leaves and clusters of burs in their axils. Locally established along ditches and in low ground in many parts of the state and seeds spread by stock and by irrigation. Rarely troublesome here in cultivated land. [Fig. 21.]

134. *XANTHIUM SPINOSUM, L. THORNY CUCKLEBUR.

Specimens of this weed have been sent in from the vicinity of Victor and the plant is said to be well established about sheep camps in the Bitter Root region, probably brought in from the Pacific Coast with imported sheep. It has burs like the preceding but the leaves are more lobed and white beneath with long, three-divided yellow thorns in the axils. It should not be allowed to secure a footing in the state lest it become a serious pest to the wool industry and to agriculture.

ADDENDA.

135. *ERODIUM CICUTARIUM, L'Her. ALFILARIA; PIN CLOVER.

A prostrate or spreading, much-branched annual with finely divided leaves and rose-colored flowers; fruit similar to that of the Geranium. Well established in waste places at Thompson Falls and Plains and is a fair forage plant. Imported from the Pacific Coast.

136. *MADIA SATIVA, L. TALL TARWEED.

Resembling M. glomerata, but is a taller plant (2 or 3 feet high) with heads terminating slender scattered branches. Frequent along roadsides and waste places at Thompson Falls, coming in from the Pacific Coast.

137. *VERBASCUM BLATTARIA, L. MOTH MULLEIN.

A smooth slender biennial 2 to 4 feet high with a cluster of toothed basal leaves and a terminal raceme of white (rarely yellow) flowers. Established along the railroad at various points west of Missoula and exhibits a strong disposition to spread. Noted at DeSmet, Weeksville and Thompson Falls.

138. *VICIA SATIVA, L. Vetch.

A European pea established along the railroad at Plains and its growth here would indicate that it might be profitably employed as a forage plant, as it is in Europe.

SUBJECT INDEX.

Figures Refer to Pages.

Adaptations of weeds, 5, 6, 9.
Alluvial weeds, 9.
Animal transportation of seeds, 8, 9.
Annuals, 6, 7, 12, 13.
Biennials, 7, 12, 13.
Burs, 8.
Characteristics of weeds, 5, 11.
Classification by situation, 13—17.
Crop-rotation, 17.
Cultivated ground, weeds of, 15.
Dissemination; Distribution, 7.
Eastward extension of weeds, 12.
Eradication, 17—22.
Fire weeds, 9.
Fleshy habit, 6.
Foreign origin of weeds, 12.
Gardens, weeds of, 5, 9, 15.
Grain fields, weeds of, 5, 9, 16, 17.
Head, 24.
Impure seed, 8, 9.
Indigenous weeds, 10, 11.
Introduced weeds, 10, 11.
Introduction, 3.
Irrigation in weed dissemination, 7, 9.
Lawns, weeds of, 5, 9, 15.
Legislation needed, 21, 22.
List of the weeds of Montana, 24—66.
Man as agent in weed dissemination, 9, 10.
Meadows, weeds of, 5, 6, 15.
Mud in weed dessemination, 14.
Native weeds, see "Indigenous weeds."
Origin of the weed flora, 9—13.
Panicle, 24.
Pasturage, 18.
Pastures, weeds of, 5, 6, 15.
Perennials, 12, 13.
Railways in weed dissemination, 8.
Reproduction, 6.
Root-system, 13.
Rules for recognition of introduced weeds, 11.
Seeds of weeds in food, 5.
Special methods of eradication, 18—20.
Spike, 24.
Subindigenes, 11.
Summer fallow, 18, 21.
Tumble-weeds, 7.
Vitality of weed seeds, 6, 21.
Waste places, weeds of, 5, 13, 14. 15.
Water in weed dissemination, 7, 9.
Waysides, weeds of, 5, 6, 13, 14, 15.
Weed flora, origin of, 9, 12.
Weed law, 22, 23.
Westward extension of weeds, 12.
Wind in weed dissemination, 7, 9.
Wool industry, relation of weeds to, 8.
Yards, weeds of, 5, 13, 14, 15.

GENERIC INDEX OF SCIENTIFIC NAMES.

Achillea, 12, 15, 25.
Agrostemma, 25.
Allionia, 12, 25.
Amaranthus, 7, 11, 12, 13, 14, 15, 25, 26, 60.
Ambrosia, 13, 14, 26, 27.
Anthemis, 14, 27, 48.
Arctium, 14, 27.
Arenaria, 14, 28.
Artemisia, 12, 14, 16, 28.
Atriplex, 14, 28.

Avena, 16, 28, 29.
Brassica, 14, 16, 30, 31.
Bromus, 14, 16, 31.
Camelina, 16, 31.
Capsella, 14, 16, 32.
Cerastium, 12, 20, 32.
Chenopodium, 11, 12, 14, 16, 32, 33.
Chrysanthemum, 33.
Cichorium, 34.
Cleome, 9, 11, 12, 14, 16, 35.
Cnicus, 11, 12, 14, 15, 16, 35, 36, 37.
Convolvulus, 19, 37.
Cuscuta, 38.
Cynoglossum, 38.
Draba, 11, 16, 38.
Dracocephalum, 11, 38.
Echinospermum, 9, 11, 12, 14, 39, 44.
Ellisia, 11, 14, 39.
Epilobium, 12, 14, 16, 19, 39.
Erigeron, 7, 13, 14, 16, 40.
Erodium, 66.
Euphorbia, 11, 12, 14, 17, 40.
Franseria, 11, 12, 14, 40.
Gaura, 11, 12, 17, 40.
Geranium, 41.
Glycyrrhiza, 12, 16, 19, 41.
Grindelia, 11, 12, 15, 20, 41.
Helianthus, 11, 12, 14, 16, 17, 41, 42.
Hordeum, 11, 12, 14, 15, 42, 43.
Hyoscyamus, 43.
Hyssopus, 43.
Iva, 7, 9, 11, 12, 14, 16, 17, 19, 43, 44.
Krinitzkia, 9, 11, 12, 44.
Lactuca, 12, 14, 16, 17, 19, 44, 45.
Lamium, 45.
Leonurus, 45.
Lepachys, 12, 15, 45.
Lepidium, 11, 12, 14, 16, 45, 63.
Lupinus, 12, 16, 19, 46.
Lygodesmia, 12, 16, 19, 46,47.
Madia, 12, 14, 46.
Malva, 46.
Malvastrum, 9, 11, 48.
Marrubium, 14, 48.
Matricaria, 12, 14, 48.
Melilotus, 48.
Monolepis, 11, 12, 14, 16, 33, 48.
Nasturtium, 49.
Nepeta, 49.
Œnothera, 11, 49.
Onagra, 49.
Panicum, 7, 12, 14, 49.
Pastinaca, 49.
Plantago, 9, 11, 12, 14, 15, 49, 50.
Poa, 50.
Polygonum, 14, 16, 17, 50, 51.
Portulaca, 26, 51.
Rumex, 12, 15, 17, 20, 51, 52, 53.
Salsola, 7, 15, 53, 54, 55, 56.
Saponaria, 17, 25, 56, 57.
Senecio, 56.
Silene, 56.
Sisymbrium, 7, 11, 12, 15, 58, 59.
Solanum, 11, 12, 13, 15, 16, 59, 60, 61.
Sonchus, 16, 60.
Spergula, 60.
Stellaria, 60.
Suckleya, 60, 62.
Symphytum, 62.
Taraxacum, 15, 62, 63.
Thlaspi, 63.
Tragopogon, 15, 63.
Urtica, 15, 63.
Verbascum, 15, 64,
Verbena, 12, 15, 64.
Veronica, 64.
Vicia, 66.
Xanthium, 12, 13, 15, 41, 64, 65.

INDEX OF POPULAR NAMES.

Alfalfa Dodder, 38. [Fig. 9].
Alfilaria, 66.
Arnica, 41.
Barnyard Grass, 49.
Bazzle-weed, 43.
Beggar-ticks, 14, 39.
Birdseed, 14, 16, 45.
Black Henbane, 43.
Black Mustard, 14, 30.
Brome-grass, 31.
Buffalo-bur, 15, 16, 60.
Burdock, 14, 27, 53.
Butterfly-weed, 40.
Canada Thistle, 6, 8, 9, 14, 15, 16, 19, 20, 21, 22, 23, 25, 36. [Fig. 7].
Careless-weed, 16, 26, 40. [Fig. 11].
Carpet-weed, 6, 40.
Carrot, 5, 30.
Catchfly, 56.
Catnip, 49.
Charlock, 31.
Cheat , Chess, 16, 31.
Chickweed, 9, 20, 60.
Chicory, 34. [Fig. 6].
Chinese Lettuce, 45. [Fig 12].
Cockle, 9, 17, 25, 56, 57. [Fig. 16].
Comfrey, 62.
Cone-flower, 15, 45.
Corn Cockle, 25.
Cottonweed, 14, 39.
Cow Cockle, 56; see "Cockle."
Crabgrass, 49.
Cranesbill, 41.
Creeping Ragweed, 26.
Cocklebur, 15, 24, 41, 64. [Fig. 21].
Curly-leaved Dock, 15, 53.
Dandelion, 6, 7, 9, 15, 19, 20, 62. [Fig. 19].
Dead Nettle, 45.
Deadly Nightshade, 59.
Dock, 6, 7, 53.
Dodder, 38. [Fig. 9].
Dog-fennel, 14, 27, 48.
Downy Brome-grass, 31.
Draba, 38.
Dragon-head, 38.
Dwarf Lupine, 16, 46.
Evening Primrose, 49.
False flax, 16, 31.
Field Draba, 38.
Field Spurry, 60.
Field Thistle, 36.
Fireweed, 7, 39, 40.
Foxtail, 14. 15, 42. [Fig. 10].
Giant Ragweed, 44. [Fig. 11].
Goosegrass, 50.
Ground Ivy, 45.
Groundsel, 56.
Hedge Mustard, 15, 59.
Henbane, 43.
Hogweed, 26.
Honey Clover, 48.
Horehound, 14, 48.
Horseradish, 49.
Horseweed, 7, 9, 14, 16, 17, 24, 27, 40, 44. [Fig. 2].
Hound's-tongue, 38.
Hyssop, 43.
Indian Pink, 14, 16, 35.
Ironweed, 16, 19, 24, 28, 39.
Jerumsalem Oak, 14, 32.
Kale, 14, 30.
Knotgrass, 6, 14, 50.
Lamb's-quarter, 32, 33. [Fig. 5].
Liquorice, 41.
Little Lupine, 16; see "Dwarf Lupine".
Lupine, 16, 19, 46.
Mallow, 47.
Maple-leaved Goosefoot, 14, 33.
Mayweed, 27.
Milfoil, 15, 25.
Milkweed, 6, 7, 16, 17, 19, 24, 44.
Morning-glory, 37.
Motherwort, 45.
Moth-mullein, 66.

Mountain Thistle, 36.
Mouse-ear Chickweed, 20, 32.
Mullein, 15, 64.
Mustard, 30; see "Black Mustard".
Native Plantain, 49.
Nettle, 63. [Fig. 20].
Nightshade, 59.
Oak-leaved Goosefoot, 33.
Orache, 7, 28.
Ox-eyed Daisy, 33.
Oyster plant, 63.
Parsnip, 49.
Pennycress, 7, 63.
Pepper-grass, 45.
Pigweed, 7, 14, 16, 26.
Pigweed Purseley, 6, 14, 15, 26.
Pin clover, 65.
Plantain, 6, 9, 14, 15, 19, 20, 50.
Poverty-weed, 14, 16, 19, 24, 33, 43, 48.
Prairie Beans, 46.
Prickley Lettuce, 45. [Fig. 12].
Purseley, 24, 26, 51.
Radish, 5, 30.
Ragweed, 7, 9, 14, 16, 24, 26, 40.
Rayless Dogfennel, 14, 48.
Red Pigweed, 14, 33.
Ribgrass, 50.
Rosin-weed, 15, 20, 41.
Running Mallow, 46.
Russian Thistle, 7, 8, 15, 20, 22, 23, 53, 54, 55. [Fig. 15].
Salsify, 15, 63.
Sandwort, 14.
Scotch Bull Thistle, 8, 14, 20, 22, 23, 36, 37. [Fig. 8].
Sheep Sorrel, 6, 15, 17, 19, 20, 51, 52. [Fig. 14].
Shepherd's-purse, 14, 16, 32.
Skeleton-weed, 46, 47. [Fig. 13].
Slough-grass, 42. [Fig. 10].
Small Tarweed, 46.
Smartweed, 51.
Snow on the Mountain, 40.
Sow Thistle, 7, 9, 16, 60.
Spurge, 17; see "Carpet-weed".
Squirrel-tail Grass, 42. [Fig. 10].
Stinkweed, 35, 60.
Stinging Nettle, 15, 63. [Fig. 20].
Strawberry Blite, 33.
Sunflower, 6, 7, 9, 14, 16, 17 18, 20, 41, 42.
Sweet Clover, 7, 48.
Tall Ragweed, 27. [Fig. 2].
Tall Tarweed, 66.
Tansy Mustard, 15, 58.
Tarweed, 14, 46, 66.
Thistle, 6, 7, 8, 15, 16, 19, 36.
Thorny Cucklebur, 65.
Tickseed, 14, 39.
Trailing Vervain, 64.
Tumble-grass, 7, 14, 49.
Tumble-weed, 6, 7, 14, 15, 25. [Fig. 1].
Tumbling Mustard, 7, 18, 20, 58, 59. [Fig. 17].
Turnip, 5, 30.
Vetch, 66.
Vervain, 6, 15, 64.
White Melilot, 48.
White Sage, 16, 28.
Wild Arnica, 41.
Wild Asparagus, 16, 19, 46, 47. [Fig. 13].
Wild Buckwheat, 16, 17, 51.
Wild Hollyhock, 48.
Wild Lettuce, 14, 44.
Wild Liquorice, 6, 16, 19, 41.
Wild Morning-glory, 6, 19, 37.
Wild Mustard, 6, 7, 9, 14, 16, 18, 20, 30, 31. [Fig. 4].
Wild Oat, 6, 9, 16, 17, 18, 20, 28, 29. [Fig. 3].
Wild Potato, 15, 16. [Fig. 18].
Wild Tansy, 25.
Wild Tomato, 6, 60, 61. [Fig..18].
Wild Turnip, 5, 30.
Willow-leaved Dock, 15, 53.
Woolly Plantain, 15.
Wormwood, 14, 16, 28.
Yardgrass, 50.
Yellow Evening Primrose, 49.
Yellow Melilot, 48.
Yellow Thistle, 60.

630.679
M9et

JAN 18 1909

BULLETIN No. 31.

MONTANA AGRICULTURAL
EXPERIMENT STATION
--OF THE--
MONTANA COLLEGE OF AGRICULTURE.

REPORT OF
GRAZING AND FEEDING TESTS.
BEEF CATTLE AND LAMBS.

I Grazing alsike clover under irrigation.
II Feeding steers for shipment.
III Feeding lambs for shipment and for local markets.
  1. Utilizing waste products of the farm.
  2. Rations of clover and grain, clover and screenings and clover only.
  3. Ration of clover vs. grain hay.
  4. Rations similar, with and without constant access to water.

BOZEMAN, MONTANA, JUNE 1901.

Gallatin County Republican,
Bozeman, Montana.
1901.

MONTANA AGRICULTURAL
EXPERIMENT STATION,

BOZEMAN, MONTANA.

STATE BOARD OF EDUCATION.

Joseph K. Toole, Governor,	Ex-Officio	Helena
James Donovan, Attorney-General,		
W. W. Welch, Supt. of Public Instruction,		
J. M. Hamilton		Missoula.
J. P. Hendricks		Butte.
N. W. McConnell		Helena.
O. F. Goddard		Billings.
O. P. Chisholm		Bozeman.
J. G. McCay		Hamilton
G. T. Paul		Dillon.
N. B. Holter		Helena.

EXECUTIVE BOARD.

Walter S. Hartman, President	Bozeman.
John M. Robinson, Vice-President	Bozeman.
Peter Koch, Secretary	Bozeman.
Joseph Kountz	Bozeman.
E. B. Lamme	Bozeman.

STATION STAFF.

Samuel Fortier, Ma. E	Director and Irrigation Engineer.
F. W. Traphagen, Ph. D., F. C. S	Chemist.
Robt. S. Shaw, B. S. A	Agriculturist.
J. W. Blankinship, Ph. D	Botanist.
R. A. Cooley, B. Sc	Entomologist.

Postoffice, Express and Freight Station, Bozeman.

All communications for the Experiment Station should be addressed to the Director,

Montana Experiment Station,
Bozeman, Montana.

NOTICE.—The Bulletins of the Station will be mailed free to any citizen of Montana who sends his name and address to the Station for that purpose.

Montana Experiment Station.

BULLETIN No. 31. - - - - - - - - - - JUNE, 1901.

GRAZING AND FEEDING TESTS.

R. S. SHAW.

INTRODUCTION.

This bulletin has been prepared especially for the farmers and stockmen of Montana. It contains a simple statement of the results obtained from pasturing cattle on clover, and from the feeding of steers and lambs. In nearly every arable portion of the state the feeding of stock for market is a new industry. Many enquiries come to us asking for information relative to the work. Hence, as the work is new, we have commenced at the beginning and tried to secure the most important and practical data first. The more theoretical and scientific lines relating to this work we hope to take up later.

PART I.

Pasture Experiments.

In the month of June, 1900, an experiment was started to determine the productive capacity of our irrigated clover lands, under a grazing system. In other words to find how many animals a given area could support during the growing season, the number of pounds increase in the live weight and the value of this increase.

Land Chosen.

This consisted practically of five acres, 5.04 by measure, fenced off from an alsike field, which had been seeded down during the sum- of 1897. The soil consisted of a deep, rich humus, somewhat loamy. with a gravelly subsoil. This lot was divided into two parts about equal in size. The two lots were irrigated alternately every two weeks from June 13 to August 18, and pastured in the same way. As the season was late. the animals were withheld until June 9, 1900, in order to give the clover a good start. It would have been better, however, to have turned them on a week earlier, as there was some loss owing to a rank growth of stems, which rendered the food less edible.

Animals Used.

These consisted of 12 high grade Shorthorn and Hereford yearling steers, and later seven grade Jersey heifers, one and two years old. The steers were thin at the time when put on the pasture. They had come from the range in April and had been kept on slough grass pasture up the time of going on clover. The steers were turned on the clover June 9, and the heifers June 18. The animals remained on this lot continuously to the first of October, with the exception of a few days early in August during which the pastures were too wet. Throughout this short interval they were maintained on a timothy pasture which had been closely grazed and would not provide more than enough for maintenance. Water was supplied by means of an open ditch running across the bottom of the pasture.

Gains Made by Steers on Alsike Pasture.

Weight April 14. 1900, when shrunk, 12 steers, 5820 lbs., average	485 lbs.
" June 9, " when put on alsike, 12 steers, 6540 lbs., average	545 "
" Oct. 1, " when removed from alsike, 11 steers, 8613 lbs, av'ge	783 "
One steer died from bloat on August 24, then weighing 721 lbs.	
Gain made by steer which died, June 9 to August 24	176 "
Gain made by 11 steers, from June 9 to Oct. 1st	3278 "
Total Gain	3454 "
Gain per day per head while on pasture	2.75 "

Gains Made by Jersey Heifers Grazing With Steers.

Weight June 18, 1900, 7 heifers	4575 lbs.
" Oct. 1, " " "	5681 "
Total gain from 7 Jersey grade heifers	1106 "
Gain per head per day while on pasture	1.69 "

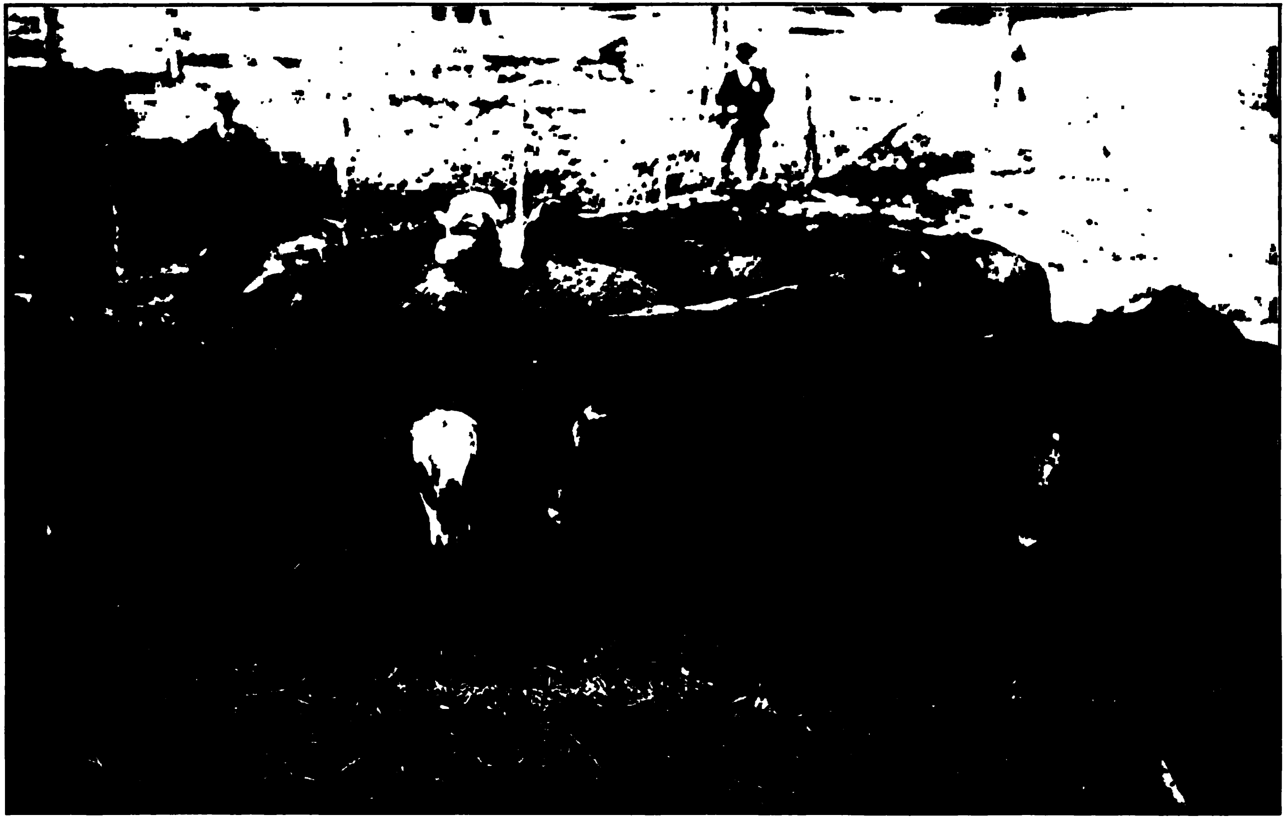


FIG. 1. YEARLING STEERS FATTENED ON CLOVER AND BARLEY, PRECEDED BY CLOVER PASTURE

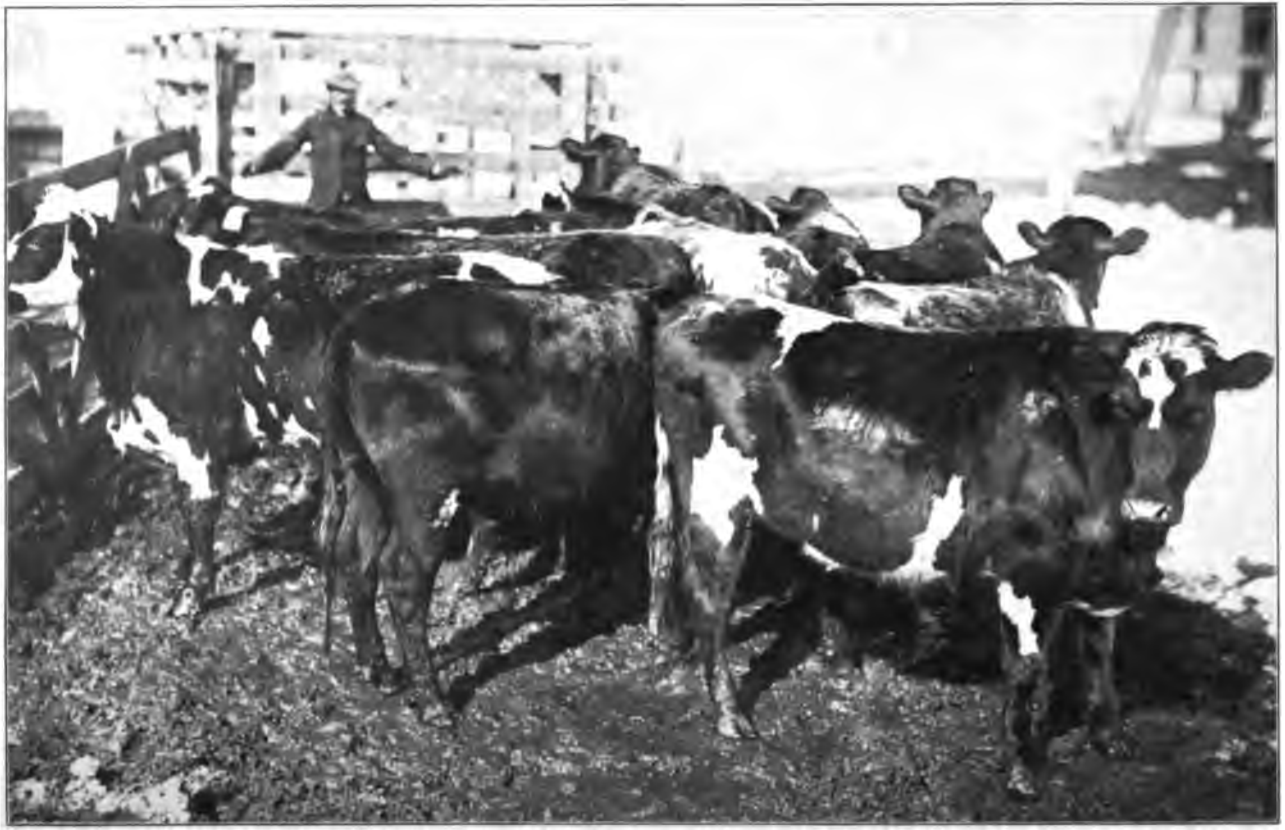


FIG. 2. YEARLING STEERS FATTENED ON CLOVER AND BARLEY, PRECEDED BY RANGE PASTURE

Relative Gains.

An instructive feature of this experiment is brought out in the relative gains made by the beef steers as compared with the Jersey grade heifers. In the case of the steers, a gain of 2.75 lbs. per head, per day, was made, in comparison with 1.75 lbs. from the heifers. It should be said of the steers, however, that they were very thin at the time of going on the clover, hence, they not only grew rapidly but fattened very fast as well. Some of the heifers were a year older and comparatively in better flesh. The results, however, tend to indicate the greater meat producing powers of the steers, and that for this special purpose beef blood is essential.

Capabilities of Alsike for Pasture Under Irrigation.

One question more freely asked than any other is "What area of clover is necessary to support a given number of animals throughout the growing season?" It was for the purpose of answering the above question that this test was made. The following is a statement of the number of days a given number of animals were kept on the 5.04 acres :

The 11 beef steers were on the pasture the equivalent of 108 days.

The 7 Jersey heifers were on the pasture the eqivalent of 93 days.

Trom the time of turning on the pasture these animals were only removed once for a few days on account of irrigation and this has been considered in the computation. The 5.04 acres of alsike therefore not only maintained the eighteen steers and heifers for 102 days but enabled them to make a very profitable gain.

Gains, in Pounds Increase from 5.04 Acres Alsike.

Total increase from 11 steers	3278 lbs.
" " " 1 steer which died	176 "
" " " 7 heifers	1106 "
Sum total	4560 "

Cash Value of the Increase in Live Weight.

4560 lbs. gain at 4c. per pound	$182.40
Cash return from each acre	36.19

The Only Source of Danger.

This arises from loss by bloating. As already stated one steer died from bloat on August 24, 1900. This took place on a warm, bright morning following two days of drizzling rain, but while the pastures were still wet. Each individual has his own theories as to the conditions which cause bloating, and yet no one seems to hold good, for it takes place under an endless variety of conditions and is a great menace to the pasturing of clovers and alfalfa. It has been claimed by many that alsike is less liable to cause bloating than red clover or alfalfa and this seems to be true to some extent.

Results Encourage Grazing by the System Outlined.

The possibilities for securing large returns from pasturing alsike, red clover and alfalfa are very great. In fact the results from this, the initial experiment, may seem overdrawn, but such are the facts. It must be remembered, however, that each half of the tract pastured was irrigated every two weeks. As an illustration of the productiveness of clover in the Gallatin Valley, we wish to call attention to the marvelous results obtained from the red clover hay which was secured from a portion of the Station farm during the summer of 1900. This tract of red clover, including 7.26 acres, at two cuttings, yielded 36 tons, 918 lbs., of well cured hay. It was irrigated three times, once before the first and twice before the second cutting. There was thus a return of 5.02 tons of red clover per acre from two cuttings.

As regards the productive and grazing power of red clover and alfalfa, in comparison with alsike, we as yet have not secured any data. This question will be tested as soon as the proper conditions can be secured. It is our opinion, however, that alsike will stand tramping and close grazing much better than red clover. It is a thick, matty, persistent grower. On a rich soil, with an abundance of water, its productive power is very great.

PART II.

Fattening Beef Cattle.

There is a growing demand for fat cattle to supply our local markets, which is worthy of the attention of the Montana stockman and farmer.. Hitherto, the state has produced large numbers of fat cattle from its ranges, but these have all reached a finished condition at one season of the year and, consequently, have had to be shipped at that time in order to prevent loss from scanty food supplies and severe weather. Conditions, however, are rapidly changing with the settlement of the rich valleys which are being brought under irrigation. In many places the large stock owner is now able to supply food for his breeding herds or flocks during the winter season. In other sections, devoted more largely to strictly agricultural work, the farmer can produce enormous quantities of forage which cannot be disposed of to better advantage than in the fattening of live stock during the winter season. It is possible for our farmers not only to supply the local demand for beef and mutton throughout the year, but to prepare large number for shipping as well. During 1899-1900 steers were successfully fattened by this Station and placed on the local market as reported in bulletin 27. The following winter of 1900-1901 others were fattened, not so much for the purpose of carrying out feeding tests as for making a shipping trial.

Amimals Fed.

These consisted of the 11 steers used in the clover grazing experiment on the station farm during the summer of 1900, and also twenty steers secured from the range. Both lots were yearlings and mostly Shorthorn grades with one or two showing some Hereford blood. Those pastured on clover were in very much better flesh when put on feed, as the ranges of the autumn of 1900 were very scant. The twenty range steers were also at the disadvantage of having to be dehorned a few days before feeding began. The latter were purchased on Oct. 15, 1900, and both lots were given the run of the Station farm until Nov. 13, at which time they were put on feed. Their food during this time consisted of such material as could be gleaned from 112 acres of stub 57 of which was clover. Representatives of these two types are sho in Figs. 1 and 2 before shipping.

On Nov. 13, 1900, the steers were divided into three lots, weigh and put on feed. The divisions were made according to quality. L (1) used in the pasturage experiment, showed the largest infusion beef blood, lot (2) a close second and lot (3) the least typical.

The objects chiefly sought were, first, finished condition from t use of clover as roughage with a minimum amount of grain, an second. the profits which could be secured from shipping.

Total Food Consumed.

Lot I.,	11 steers,	clover	from November 13, 1900, to March 30, 1901	37,455	lbs
" I.,	11 "	barley meal	from " " " " " "	7,530	"
" II.,	10 "	clover	" " " " " " "	29,335	"
" II.,	10 "	barley meal	" " " " " " "	7,315	"
" III.,	10 "	clover	" " " " " " "	29,235	"
" III.,	10 "	barley meal	" " " " " " "	7,380	"

Average Amount of Food Consumed per Day.

Lot	I	Clover hay consumed per head per day	24.8	lbs.
"	I	Barley meal " " " " "	5	"
"	II	Clover hay " " " " "	21.4	"
"	II	Barley meal " " " " "	5.34	"
"	III	Clover hay " " " " "	21.33	"
"	III	Barley meal " " " " "	5.39	"

Increase in Live Weight from Food Fed.

Lot I, 11 steers, weight Nov. 13, 1900,	9060	lbs.,	average	823.6	lbs.
" I. 11 " " Mar. 30, 1901,	12075	"	"	1097.7	"
Total gain	3015	"	"	247.1	"

Average daily gain per head during 137 days, 2 lbs.

Lot II. 10 steers, weight Nov. 13, 1900,	7985	lbs.,	average	798.5	lbs.
" II. 10 " " Mar. 30, 1901,	10395	"	"	1039.5	"
Total gain	2410	"	"	241.0	"

Average daily gain per head during 139 days, 1.75 lbs.

Lot III. 10 steers, weight Nov. 13, 1900,	7375 lbs.,	average	737.5 lbs.
" III. 10 " " Mar. 30, 1901,	9720 "	"	972.0 "
Total gain...........................	2345 "	"	234.5 "

Average daily gain per head during 137 days, 1.71 lbs.

Attention is called to the fact that the amount of food used was small considering the gains made. This may be attributed in a large measure to the quality of the food. The clover consisted of both first and second cutting hay, which had been cured in perfect condition under a cloudless sky. This clover retained all the blooms, which presented the same colorations they possessed on the day of cutting.

Throughout the 137 days during which the steers were fed there was not a single pound of waste from the roughage. Attention is also called to the fact that not more than one-half pound of barley meal, per 100 lbs. live weight, was fed each day. This is the amount which we had planned to follow throughout the feeding period. We believe that not more than this is nscessary to give maximum results when fed along with roughage of the quality which can be produced in Montana We are also convinced that maximum gains can be secured in cattle feeding in this state from a minimum amount of food. This is due to two agencies, first, an unexcelled quality of food, and, second, climatic conditions which are most favorable, viz., continual sunshine, proper temperature and quiet atmosphere.

Cost of Foods Used.

Lot I. Hay fed, 37,445 lbs., at $5.00 per ton........	$ 93.63.
" I. Barley meal feed, 7530 lbs., at 70c. per cwt...	52.71.
Total value......................	146.34.
Cost per 100 pounds increase (including maintenance)	4.85.
Lot II. Hay fed, 29,335 lbs., at $5.00 per ton........	$ 73.33.
" II. Barley meal fed, 7315 lbs., at 70c per cwt.....	51.20.
Total value......................	124 53.
Cost per 100 pounds increase (including maintenance)	5.16.
Lot III. Hay fed, 29,235 lbs., at $5.00 per ton........	$ 73.08.
" III. Barley meal fed, 7380 lbs., at 70c. per cwt...	51.66.
Total value......................	124.74.
Cost per 100 pounds increase (including maintenance)	5.31.

In the figures above given attention is called to the fact that the cost of increase diminishes according to the quality of the animals fed.

Financial Statement.

Nov. 13, 1900,	To 31 steers at $25.00 per head		$775.00.
Mar. 30, 1901,	To cost of feed, Lot I.........		146.34.
" " "	" " " " II........		124.53.
" " "	" " " " III.......		124.74.
" " "	" " shipping to Seattle		150.80.
April 6, 1901,	By 31 steers, 28880 lbs, at 5c...	$1444.00.	
" " "	To net profit..................		122.59.
		$1444.00	$1444.00.

Net profit per head, $3.95.

It will be noticed that feeding these yearling steers for 137 days, securing an average price for the food consumed by them and defraying all expenses, there was left a net profit on the carload of $122.59, or $3.95 per head. These steers were shipped to Seattle. Had there been a sufficient number of cars in the shipment to secure passage by stock train time, the shrinkage would not have been so great and the net profit relatively larger. The officials of the Northern Pacific railroad were extremely obliging in forwarding our car of cattle as expeditiously and comfortably as possible.

PART III.

Lamb Feeding Experiments.

These comprised the third series which have been conducted consecutively. The object sought has been to secure data relating to the fattening of lambs under Montana conditions and with home grown foods. The work of 1898 and 1899 consisted of a test of the comparative values of alfalfa, red clover and alsike hays, in which results were obtained showing that there was comparatively little difference among them. In 1899-'00 tests were made as to the gains and cost of production with the following rations, viz: (1) clover alone, (2) clover and unmarketable wheat, (3) clover and oats, with the following results:

From ration (1) a gain of 8.1 lbs per head, per month, at a cost of $3.54 per 100 lbs. increase; from ration (2) 10 lbs. per head per month, at a cost of $3.22 per 100 lbs. gain; and from lot (3) 10.5 lbs. per head, per month, at a cost of $4.49 per 100 lbs. gain.

During the feeding season of 1900 and 1901, the following tests were made: A comparison of the results from the following: first, the feeding of clover and marketable grain, viz: Oats and barley, second, the feeding of clover and screenings, and third, the feeding of clover alone. A test was also made between clover and grain hay. The difference in results was also ascertained between two lots fed on the same ration but one with constant access to water and the other with water but once each day. A sixth lot was also fed, but not under experiment, the object being to produce a superior quality of lamb for the home markets.

Animals Used.

These consisted of grade Merinos, showing some Leicester and Cotswold blood; they had been reared on the range and were thin at the time of purchase, Oct. 15, owing to the scarcity of food on the ranges during the autumn of 1900. In all 225 lambs were purchased, not picked. but cut out from a flock of several hundred. At the time of purchase these lambs averaged 50.86 lbs. The purchase price being $2 per head, the cost per cwt. amounted to $3.95. After having been weighed these lambs were given the run of the farm for thirty days. When the crop had been secured, 112 acres of the Station farm became available for pasturage. This area consisted of stubble from the following crops, viz: 14 acres of oats, 7 acres of wheat, 10 acres of barley, 12 acres of peas, 4 acres of plat grain, 4 acres grain hay and 4 acres of root and potato ground. The balance comprised 57 acres of clover stubble, five of which had been pastured closely throughout the season and two cuttings removed from the balance. The barley and wheat stubble grounds both possessed good stands of clover. On Oct. 15, 1900, 230 lambs went on the fields, weighing 11699 lbs., averaging 50.86 lbs. On Nov. 15, these were removed to the feed lots after having weighed 13948 lbs., averaging 60.64 lbs. The increase was therefore 9.78 lbs. per head for the month. This increase, which is large, was no doubt due to the great variety of food secured and the great abundance of the same. The benefit thus derived is a double one, arising, first, from the conversion of waste products into meat, and, second, to the thorough cleaning which the farm received.

Test No. 1.

This was made up of three lots of lambs of 53 each, with like yard and shed accomodation and constant access to an abundance of pure water which ran through the yards. Lot I was fed on clover and a grain ration of oats and barley, consisting of No. 1 marketable grain. Lot II received clover and screenings and Lot III clover only.

Food Consumed and Cost.

Lot I.	Nov. 16, 1900, to Fed. 13, 1901,	clover hay 13872 lbs at $5 per ton....	$ 34.68
" I.	" " " " " "	grain 2686 lbs at 85c. per cwt........	22.83
Total..			57.51

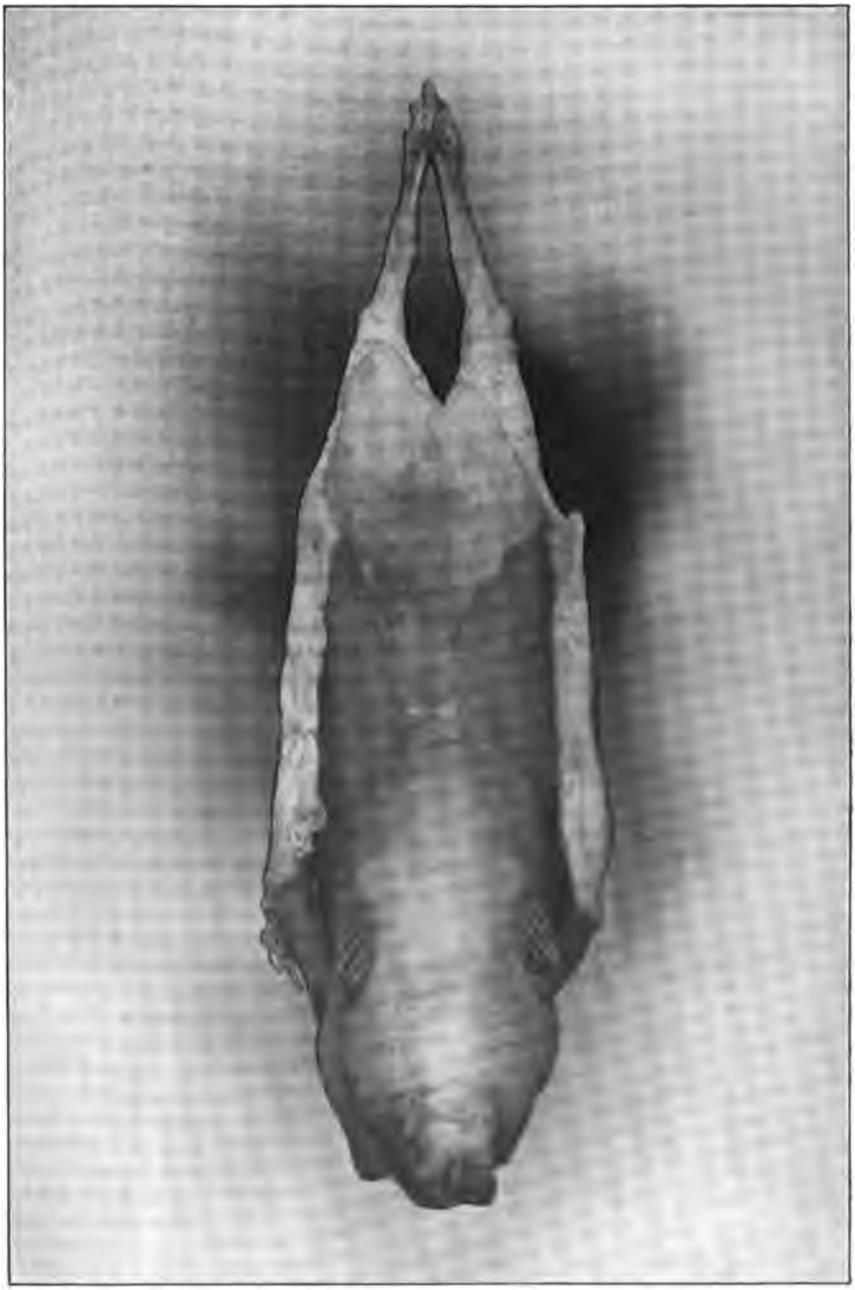


Fig. 5. Back View of Fig. 3

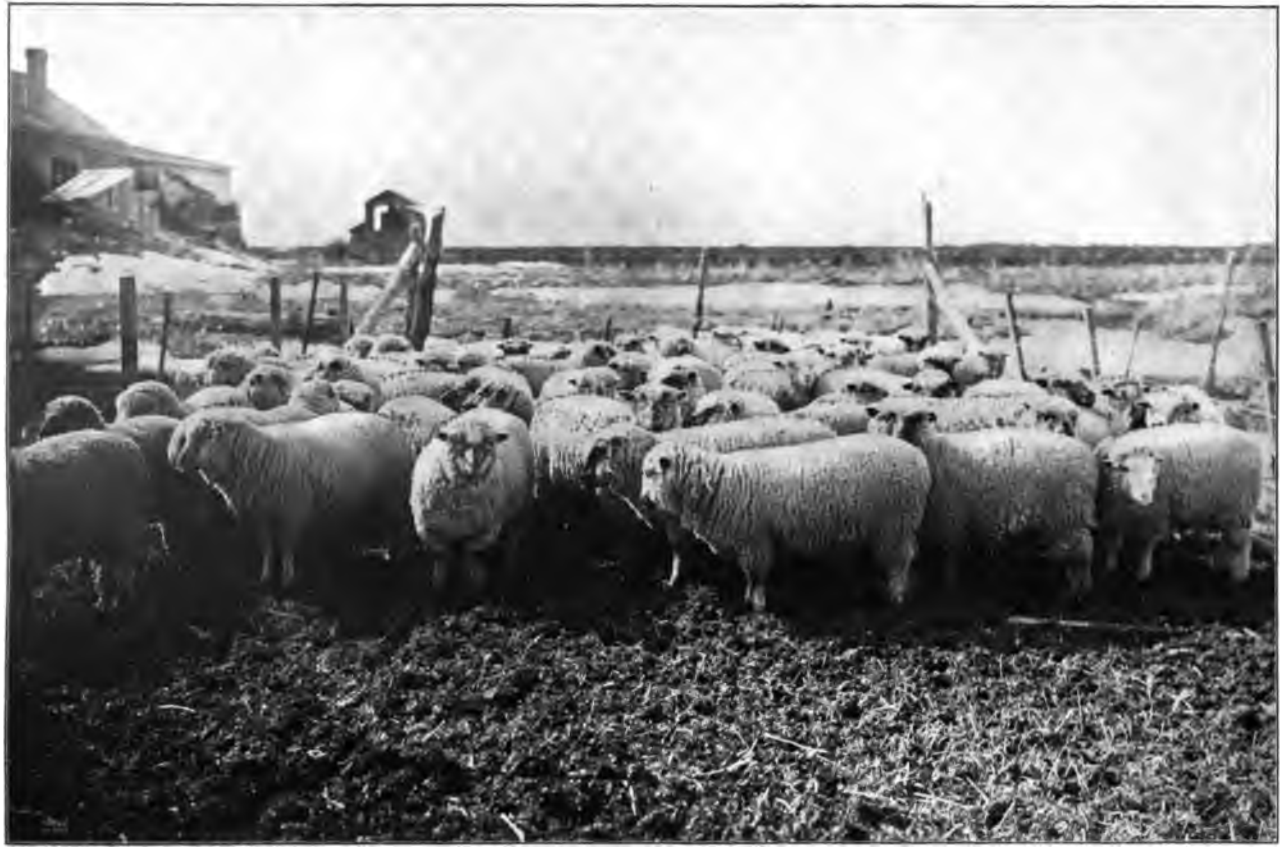


Fig. 6. Shropshire Grade Lambs. Age, 11 Months. Average Weight, 119.5 Lbs.

Lot II. Nov. 16, 1900, to Feb. 13, 1901, clover hay, 14055 lbs. at $5 per ton..	$ 35.13
" II. " " " " " Screenings 2659 lbs. at 55c per cwt....	14.62
Total..	49.75
Lot III. Nov. 16, 1900, to Feb. 13, 1901, clover hay, 15875 lbs at $5 per ton..	39.68
Total..	39.68

It will be noticed in Lot I, where clover and marketable grain were fed, that the cost of feeding is raised high above the other two because of the costliness of the grain and that as hereafter pointed out the increase was not enough to counterbalance the extra expense. Also that while the food of Lot III cost the least, the increase was not sufficient to render it the cheapest producer in the end.

Gains Made.

Lot I. 53 lambs, weight Nov. 16, 1900,........	3215 lbs.,	average	60.66	lbs.
Lot 1. " " " Feb. 13, 1901.........	4538 "	"	85.62	"
Total gain...........	1323 "	"	24.96	"
Lot II. 53 lambs, weight Nov. 16, 1900.......	3260 lbs.,	average	61.5	lbs.
Lot II. " " " Feb. 13, 1901.....	4748 "	"	89.58	"
Total gain..........................	1488 "	"	28.08	"
Lot III. 53 lambs, weight Nov. 16 1900.....	3245 "	"	61.22	"
Lot III. " " " Feb. 13, 1901.....	4366 "	"	82.37	"
Total gain..........................	1121 "	"	21.15	"

Relative Amounts of Food Consumed.

Lot I.	Clover consumed per head per day	2.9	lbs.
" I.	Grain " " " "	.56	"
" II.	Clover " " " "	2.94	"
" II.	Screenings " " " "	.55	"
" III.	Clover " " " "	3.32	"

Relative Cost of Production.

Lot I.	Cost per 100 pounds increase including maintenance	$4.34
" II.	" " " " " " "	3.34
" III.	" " " " " " "	3.53

We conclude, therefore, that the most satisfactory results were secured from the ration of clover and screenings. More profitable because the increase was greater and the cost of production less. That the per capita gains should be greater from the lot fed screenings than those receiving first class grains may seem strange, but such are the results of this test. While Lot I received a few pounds less hay than Lot II this was about offset by their having received a little more grain. From practically the same number of pounds of food fed, Lot II receiving screenings, made a greater gain by 165 pounds than Lot I, receiving grain. While this is contrary to the general expectation, it no doubt depends largely upon the character of the screenings and the variety which it affords. In this case they were second screenings, containing an endless variety of grain and weed seeds and practically no light or chaffy material. In addition to the larger gain, the screening fed lambs cost $1.00 less per hundred pounds increase. While the gains and cost of production from the clover fed lot were moderate, still they were not so satisfactory as those from Lot II, for the reason that the lambs were not in as good condition for market nor for withstanding the hardships of shipping.

We conclude, therefore. that it is best to use some grain along with alfalfa or clover in preparing lambs for shipping, that a large amount is not necessary because of the quality of our coarse foods. Not more than one-half pound of grain per day throughout a feeding period of ninety days, or the equivalent of this if fed only throughout the latter portion of the period. This will of course only apply in those cases where Montana grown legumes are used as roughage. Where first-class marketable grains are used it makes the ration too expensive. Good results can be secured from screenings or from cheap or unsalable grains.

TEST NO. 2.

Clover and Grain Hay Compared.

In many sections of Montana grain hay is grown to a large extent. It is most commonly grown at altitudes too high for the maturing of the grain or on foul tracts of land where weeds are being combatted. It has been used most extensively as a food for horses or for wintering over cows and calves. Enquiries have come regarding its use as a fattening food, which lead us to secure data relative to its value for fattening lambs.

For this purpose, 7.38 tons were grown upon an area of 3.7 acres. Thus, while the yield is large, it does not give more than half the fodder secured from the same area of clover. The grains mixed for sowing were spring wheat, barley, oats and peas in equal amounts. This mixture was drilled in, irrigated twice during the summer and cut and cured as for hay when in the milk stage. Because of the bright, rich appearance of this fodder, intermixed with a good strong growth of peas and containing much immature grain, we expected excellent results from it.

Two lots of lambs of 53 each were used, one receiving clover and the other grain hay. One of these lots was the same as that used in the preceding test. The test was not conducted longer than 60 days because of the supply of grain hay giving out, some of which had been used for other purposes. These two lots were put on feed on Nov. 16, 1900, all other conditions except those of food being practically the same.

Food Consumed.

By 53 lambs receiving clover only,—

From Nov. 16, 1900, to Jan. 14, 1901, 10780 lbs. clover at $5 per ton....$26.95.

By 53 lambs receiving grain hay only,—

From Nov. 16, 1900, to Jan. 14, 1901, 10420 lbs. grain hay at $5 per ton $26.05.

Increase in Weight.

Nov. 16, 1900, weight clover fed lambs,	3245 lbs.,	average...	61.22 lbs.
Jan. 14, 1901, " " " "	3987 "	" ...	75.22 "
Total gain.....................	742 "	"	14.00 "
Nov. 16, 1900, weight hay fed lambs,	3210 lbs.,	average...	60.56 lbs.
Jan. 14, 1901, " " " "	3776 "	" ...	71.24 "
Total gain.....................	566 "	" ...	10.68 "

Therefore, during the 60 days trial the clover fed lambs made a gain of 14 lbs. per head, while those receiving grain hay gained only 10.68 lbs. each. Throughout this period of 60 days the clover lot produced 100 lbs. gain at the rate of $3.63, as compared with $4.60 from the grain hay. It should be noted, however, that a small amount more clover was consumed than grain hay, but not sufficient to materially affect the data.

While these figures represent in a practical way the comparative feeding values of clover and grain hay for fattening lambs, still, they may not represent accurately their relative food values for other classes of stock or from a standpoint of composition. While horses and cattle consume these readily there was much waste from the lambs, consisting of grain stems and vines of peas. The results from the use of the grain hay fell far below our expectations.

TEST NO. III.

Effect of Water Supply on Fattening Lambs.

The impression prevails to some extent, fortunately not, however, among experienced sheep men, that a sheep can thrive and even fatten with the use of much less water than is really necessary. We, therefore, made it a part of our work to secure data relating to the results obtained from lambs on similar rations where in one case they had constant access to water, while in the other they were turned to water but once a day. In this case we were unable to handle a full pen of 53 lambs in each lot. Seventeen lambs of like quality, but a trifle, lighter were chosen and fed on the same food and in the same manner as Lot II, heretorore described as receiving clover hay and screenings. The seventeen lambs were given access to water but once a day while those of Lot II had constant access to water which ran through their yards.

Food Consumed by 17 Lambs.

From Nov. 16. 1900, to Feb. 13, 1901, clover 4722 lbs, at $5 per ton..........	$11.80
" " " " " " " screenings 884 lbs., at 55c. per cwt.....	4.64
Total...........	$16.44

Gains Made by 17 Lambs.

Nov. 15, 1900, weight	961	lbs., average	56.53	lbs.
Feb. 13, 1901, "	1326	" "	78.00	"
Total gain........	365	" "	21.47	"

Average amount of Food fed per day to Lambs Watered Once a day.

Clover consumed per head per day	3.08 lbs.
Screenings " " " " "	.55 "

Average Amount of Food fed per Day to Lambs with Water.

Clover consumed per head per day	2.94 lbs.
Screenings " " " " "	.55 "

Comparative Gains.

Lambs with constant access to water gained	9.36 lbs. per month.
" watered but once a day, "	7.15 " " "

Comparative Cost of Increase.

Lambs with constant access to water	$3.34 per 100 lbs. gain.
" watered but once a day	$4.51 " " " "

It will thus be seen that a constant supply of pure water in the feeding pens materially affects both the increase in live weight and financial returns. From these two lots, fed the same food under precisely the same conditions except as to watering, those having constant access to the water made a larger gain per head per month by 2.21 lbs. and also produced 100 pounds gain at the rate of $1.17 less. This data emphasizes strongly the necessity for a constant supply of pure water for fattening lambs.

FINANCIAL STATEMENT.

In all 225 range lambs were purchased and put on feed to which 4 others were added. Of these 516 only will be considered in our financial statement as they comprised the carload which reached Chicago. The remainder were used for slaughter and placed on the local market.

Food consumed by 229 lambs from Nov. 16, 1900, to Mar. 15, 1901:

Clover, 65919 lbs. at $5 per ton	$164.79.
Grain hay, 10420 lbs. at $5 per ton	26.05.
No. 1 grain, 3446 lbs. at 85c. per cwt	29.29.
Screenings, 4515 lbs. at 55c. per cwt	24.83.
Total cost of food for 229 lambs	$244.96.
Cost of food per lamb	1.06.
Cost of food for 216 lambs shipped	230.90.

Nov. 15, 1900, to 216 lambs at $2 per head		$ 432.00
Mar. 15, 1901, to cost of food 120 days		230.90
Mar. 15, 1901, to freight, feed, yardage, commission, etc		181.39
Mar. 27, 1901, by 216 lambs sold in Chicago	$908.29	
Mar. 27, 1901, by net profit		64.00
	$908.29	908.29

Net profit per head .30.

After the ninety day feeding test had closed the lambs were held for a number of days, as shown by the data. This was done in order to join other shipments and to take advantage of the rise in price. During this interval the gains were very unsatisfactory due to the annoyance and injury of many of the lambs by dogs from the city, the feeding yards being but a few hundred yards from the city limits. During the first visitation no less than forty lambs were bitten, a few dying afterwards. Though precautions were taken to prevent dogs from gaining access to the yards their presence in the vicinity at night kept the lambs constantly in a state of nervous excitement which rendered the feeding very unsatisfactory.

Shrinkage.

Before shipping the lambs were taken from the feed yards and weighed, averaging 88 pounds per head. At the time of sale in Chicago the average weight was 80 pounds. The lambs were six days on the road between Bozeman and Chicago, there being but two cars of sheep in the train. We believe that this shrinkage is much larger than would take place when running on regular stock train time and with better conditions for feeding.

Unfortunately a heavy fall of snow preceded the shipment which, having melted, made it difficult to feed along all lines owing to water and mud.

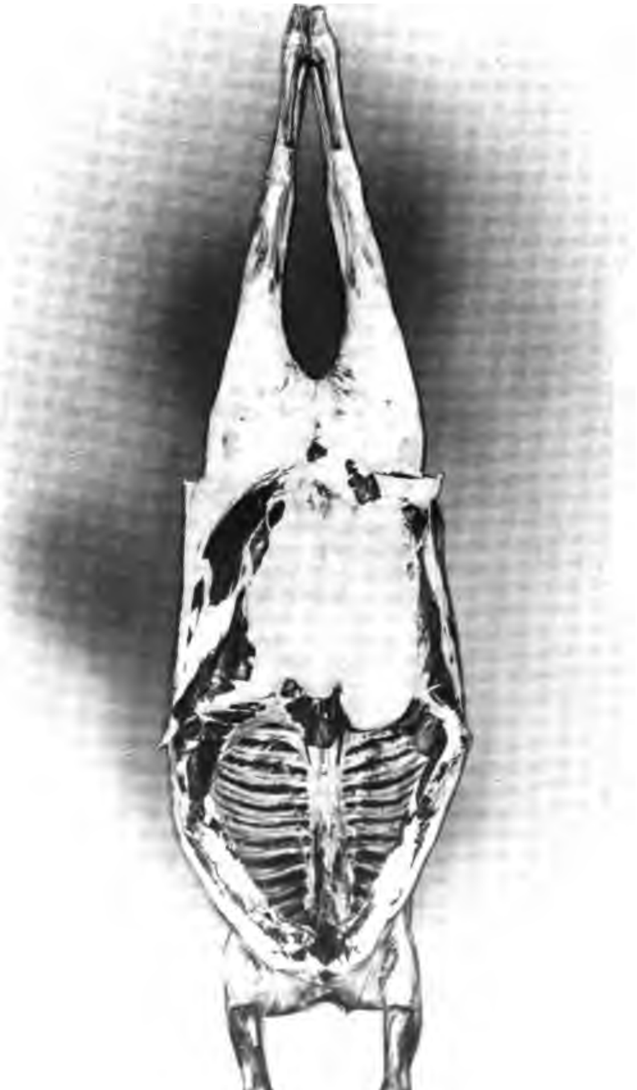


Fig. 4. Carcass of Lamb Grown on Range and Fattened on Clover. 11 Months Old; Weight 54 Lbs.

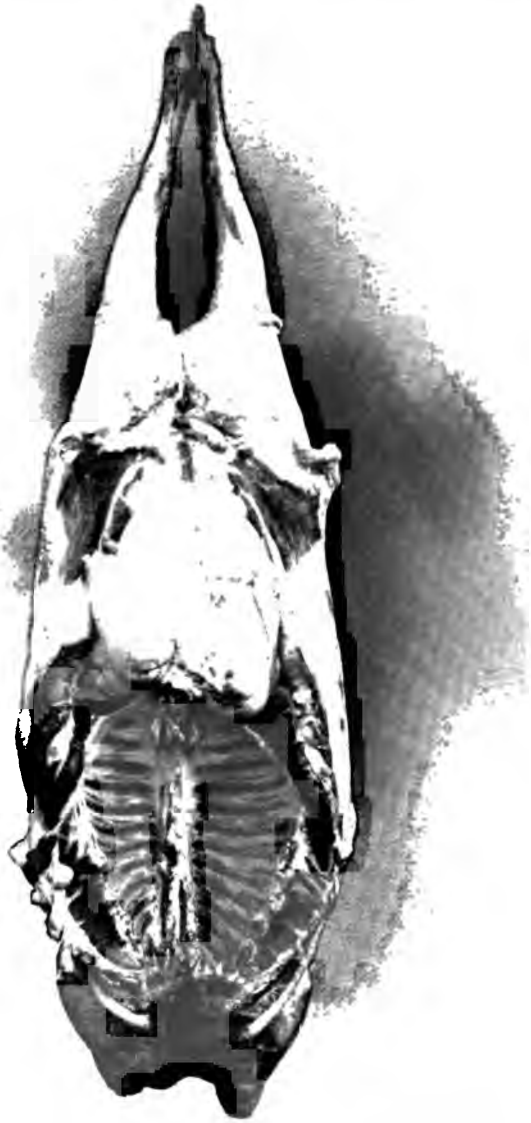


FIG 3. CARCASS OF LAMB 11 MONTHS OLD, GROWN ON CLOVER RANCH. WEIGHT, 74 LBS.

Market Prices Received.

The price received for the majority of these lambs in Chicago was $5.30 per cwt., within ten cents of the top market price on the day of sale; some of the thinner ones sold at $5.20. Because of the fact that this car lacked uniformity, consisting of lambs from five pens, each fed differently and some without any grain, we were well pleased with the sale. The lambs were sold by Messrs. Clay, Robinson & Co., of the Union Stock Yards, Chicago. These gentlemen were exceedingly diligent in keeping us posted as to the market conditions and the best time to forward the lambs. By acting on their advice we were enabled to secure the advantage of advanced prices after a depression extending over some two months, as shown by the market reports.

Fattening Lambs for the Local Market.

In order to seek further information regarding the demands of our local markets 59 high grade Shropshire lambs were purchased from Mr. Roy Martin, of Bozeman, on Nov. 1st, 1900, and fed during a period of 135 days. At the time of purchase these lambs averaged 78.5 lbs. and the purchase price being $3.00 per head, cost $3.82 per cwt. The cost of feed for these lambs during 135 days was $1.56 per head. These lambs were placed on the Bozeman market at a weight of 119.5 lbs. each. The price received for them was $5.25 per head or $4.40 per cwt. After charging up the feed at prices already given a net profit of 69 cents per head was realized. This profit would probably have been still larger had the lambs been disposed of earlier in the season, as they were fed beyond a condition of perfect finish. Figs. 3 and 5 show both front and rear cuts of a carcass from this lot which dressed 74 lbs. Fig. 6 shows the band of grade Shropshires which were fed and sold on the local markets.

Conclusion.

The data relating to stock feeding furnished in this bulletin is given to the farmers and stockmen of Montana with the hope that it may at least provide some useful information relating to the feeding of stock for shipment. We wish to call particular attention to the fact that these statements may be regarded as very safe, for two reasons, first, where larger numbers are being purchased they can be secured more cheaply. While we paid $2 per head for 225 lambs a band of 1300 near by was purchased for $1.75 each; second, the market at the time our lambs were sold, though better than for some weeks, was much lower than the average the same season during a number of years past.

According to reports the western feeder came out about even during the past season; the live stock reports show this to have been the case. In the face of this fact, then, is it not encouraging to know that the shipment from this station netted a fair profit.

We cannot urge too strongly the practicability of sheep feeding in particular in our Montana valleys. Use alfalfa, red clover, or alsike with a small amount of grain. The secret of success in the future will be found in finishing a product better than the average which reaches the market. Those are the kind which feed and sell profitably.